

9.6 MEASURES TO AVOID JEOPARDY

9.6.1 Hydro Measures

9.6.1.1 Overview

Operational and structural fish passage improvements at FCRPS projects are proposed to increase the survival of listed fish. This section describes the specific hydro measures that NMFS has determined, based on the best scientific information, to be as follows:

- Biologically feasible and implementable
- Sufficient to achieve performance standards that represent the best the hydrosystem can do without dam breaching
- Sufficient to result in a high likelihood of survival and a moderate-to-high likelihood of recovery, combined with offsite mitigation defined in Sections 9.6.2, 9.6.3, and 9.6.4 of this biological opinion and with other improvements affecting the listed species described in the Basinwide Recovery Strategy

The hydrosystem measures are expected to reduce juvenile and adult salmonid mortality attributable to passage through the hydrosystem and to attain the hydro performance standards by 2010. Their main features are described briefly below.

Proposed measures for improving water management so as to provide direct and indirect survival benefits to salmon include the following:

- Meet flow objectives at Lower Granite, Priest Rapids, McNary, and Bonneville dams.
- Provide in-season management for operational flexibility and best use of available water volumes.
- Provide guidance on reservoir elevations in early spring, early summer, and at the end of the summer flow augmentation season.
- Coordinate with water releases from Canada, the upper Snake River, and the Hells Canyon Complex.
- Take specific actions to improve water management for salmon: 1) additional drafts of selected FCRPS reservoirs, 2) additional water from other sources, 3) shifts of flood control among projects, 4) implementation of VARQ flood control operations at Libby and Hungry Horse reservoirs, 5) review of system flood control objectives, and 6) continued research on summer-migrating SR fall chinook salmon population losses.

The following actions are prescribed for improving juvenile passage survival through the FCRPS to the ocean:

- Increase spillway passage using gas abatement and longer spill hours to allow greater spill volumes; also, refine spill patterns and evaluate removable spillway weirs (RSWs) as ways of improving spill efficiency.
- Conduct research on spillway passage to identify additional potential survival and passage improvements.
- Increase screen/bypass system effectiveness with extended screens, new outfalls, and improved hydraulic conditions.
- Develop and test surface bypass technology, with implementation as appropriate.
- Provide improved turbine designs and operating guidelines.
- Improve passage system operations and reliability.

Measures for improving juvenile reservoir survival, and thereby increasing the survival of downstream migrating salmon, include the following:

- Increase flow augmentation for summer migrants, particularly in the low water years.
- Manage reservoir and run-of-river projects to reduce extreme water level fluctuations.
- Manage predator populations (fishes, birds, and mammals).

Measures for improving adult survival are as follows:

- Develop actions to reduce fallback through turbines and over spillways.
- Increase facility reliability and the ability to maintain operating criteria.
- Investigate measures to protect steelhead kelts.
- Investigate prespawning mortality.

Measures for improving water quality include the following:

- Make structural and operational modifications at spillways (e.g., spillway deflectors, improved spill patterns) to help reduce TDG levels.

- Develop alternative fish passage measures (e.g., surface bypass).
- Release cool water from storage reservoirs (e.g., Dworshak Dam).
- Institute special powerhouse operations (e.g., McNary Dam).

NMFS proposes active investigation to reduce or resolve key uncertainties. Critical uncertainties relate primarily to the hypothesis of delayed mortality due to passage through the hydrosystem:

- Investigate delayed mortality of transported juvenile migrants (D-value when expressed relative to the survival of nontransported migrants below Bonneville Dam).
- Investigate delayed mortality of inriver juvenile migrants (extra mortality).
- Investigate delayed mortality or passage effects on adults.
- Investigate estuarine/ocean survival.

Measures are also proposed for enhanced O&M of fish passage facilities. Developing appropriate annual budgets through the annual 1- and 5-year planning process will help ensure continued high performance of fish passage facilities. Preventive maintenance planning and day-to-day operation of fish passage facilities can be improved by an increased commitment to excluding debris and operating within identified criteria.

NMFS believes the strength of these measures depends not only upon scientific analysis, but also on the joint decision-making processes defined in Section 9.4. Involvement and input from the region's fish and wildlife managers and Indian Tribes are necessary to ensure that all of the best scientific and technical information is considered in the effort to avoid jeopardy.

9.6.1.2 Water Management

9.6.1.2.1 Flow Management Objectives in Mainstem Columbia and Lower Snake Rivers

Action 14: The Action Agencies shall operate FCRPS dams and reservoirs with the intent of meeting the flow objectives (Table 9.6-1) on both a seasonal and weekly average basis for the benefit of migrating juvenile salmon.

This flow-management program uses three strategies:

- Limit the winter/spring drawdown of storage reservoirs to increase spring flows and the probability of reservoir refill.
- Draft from storage reservoirs during the summer to increase summer flows.

Table 9.6-1. Seasonal flow objectives and planning dates for the mainstem Columbia and Snake rivers.

Location	Spring		Summer	
	Dates	Objective	Dates	Objective
SNAKE River at Lower Granite Dam	4/03 - 6/20	85 - 100 ¹	6/21 - 8/31	50 - 55 ¹
Columbia River at McNary Dam ²	4/10 - 6/30	220 - 260 ¹	7/01 - 8/31	200
Columbia River at Priest Rapids Dam	4/10 - 6/30	135	NA	NA
Columbia River at Bonneville Dam	11/1 - emergence	125–160 ³	NA	NA

¹ Objective varies according to water volume forecasts (see below).

² NMFS is contemplating moving the flow measurement location from McNary Dam to Bonneville or The Dalles dam by creating new objectives for Bonneville Dam (Conservation Recommendation 11.5).

³ Objective varies based on actual and forecasted water conditions.

- Provide minimum flows in the fall and winter months to support mainstem spawning and incubation below Bonneville Dam.

Under the first strategy, the FCRPS storage reservoirs are operated to ensure a high probability of water surface elevations within 0.5 foot of the flood control rule curve by April 10 and to refill by June 30, except as specifically provided by the Technical Management Team. Before the 1995 Biological Opinion, FCRPS storage reservoirs were routinely drafted well below these levels to maximize hydropower generation during the fall and winter. Meeting the spring flow objectives occasionally requires reservoir drafting, but the spring flow objectives are primarily met by limiting winter drafting and reservoir refill rates. This operation allows for a more natural spring hydrograph by passing spring runoff through the storage reservoirs.

The second strategy is used to facilitate summer operations. FCRPS storage reservoirs are drafted as necessary within specified limits in an attempt to meet the summer flow objectives and to provide colder water for the benefit of migrating juvenile salmonids. These operations may also benefit adults in passage by moderating temperatures.

The third strategy has recently been integrated into the overall flow management objective to provide habitat for mainstem spawning chum and fall chinook. It includes subsequent flows to protect the redds from dewatering through their emergence in the spring, to the extent possible without impacting refill probabilities of FCRPS storage projects and spring flow objectives.

Data collected to date regarding the effects of flow on survival of fall chinook juvenile migrants (NMFS 2000h) indicate that flows ranging from 80 to 100 kcfs measured at Lower Granite Dam during the summer migration period would be optimal for these fish. Although juvenile fall chinook survival is correlated with streamflow, survival shows similar correlations to water temperature and turbidity (NMFS 2000h). For this reason, water quality, particularly water

temperature, should be considered in determining the optimum use of available stored water volumes for flow augmentation in the Snake River. NMFS is not revising the Snake River summer flow objectives to an 80- to 100-kcfs range at this time. The existing seasonal flow objectives established by the 1995 FCRPS Biological Opinion (NMFS 1995a) represent a fair balance between flow and water quality conditions.⁶

Spring Flows at Lower Granite Dam. Based on the April final runoff volume forecast at Lower Granite Dam for April to July, spring flow objectives will be determined as follows:

- When the volume forecast is less than 16 Maf, the flow objective will be 85 kcfs.
- When the volume forecast is greater than 16 Maf and less than or equal to 20 Maf, the flow objective will be determined by a linear interpolation between 85 kcfs and 100 kcfs.
- When the volume forecast is greater than 20 Maf, the flow objective will be 100 kcfs.

Summer Flows at Lower Granite Dam. Based on the June final runoff volume forecast at Lower Granite Dam for April to July, summer flow objectives will be determined as follows:

- When the volume forecast is less than 16 Maf, the flow objective will be 50 kcfs.
- When the volume forecast is greater than 16 Maf and less than or equal to 28 Maf, the flow objective will be determined by a linear interpolation between 50 kcfs and 55 kcfs.
- When the volume forecast is greater than 28 Maf, the flow objective will be 55 kcfs.

Spring Flows at McNary Dam. Based on the April final runoff volume forecast at The Dalles Dam for April to August, spring flow objectives will be determined as follows:

- When the volume forecast is less than 80 Maf, the flow objective will be 220 kcfs.
- When the volume forecast is greater than 80 Maf and less than or equal to 92 Maf, the flow objective will be determined by a linear interpolation between 220 kcfs and 260 kcfs.
- When the volume forecast is greater than 92 Maf, the flow objective will be 260 kcfs.

Spring Flows at Priest Rapids Dam. The spring flow objective at Priest Rapids Dam will be 135 kcfs.

⁶The issue of providing water from BOR's upper Snake basin and Idaho Power Company's Hells Canyon projects to assist in achieving Snake River flow objectives will largely be addressed in separate, ongoing Section 7 consultations.

Summer Flows at McNary Dam. The summer flow objective at McNary Dam will be 200 kcfs. The best biological information supports flows of 200 kcfs for subyearling chinook salmon in the lower Columbia River. If the numbers of juvenile fish migrating during late August decrease sharply, however, the Technical Management Team should consider preserving some of the flow augmentation water to support the fall spawning operation below Bonneville Dam.

Action 15: The Action Agencies shall operate the FCRPS to provide flows to support chum salmon spawning in the Ives Island area below Bonneville Dam.

A spawning operation will be implemented as described below if the best hydrologic data available by early October indicate that precipitation, runoff, and reservoir storage are likely to support the operation from the start of spawning (late October or early November) until the end of emergence (generally through the start of the spring flow augmentation season in April). The spawning operation cannot adversely affect implementation of this RPA or the parties' ability to comply with the Vernita Bar agreement. That agreement protects natural production of unlisted fall chinook in the Columbia River Hanford Reach. If these conditions cannot be met, the Action Agencies will work with NMFS and regional salmon managers to identify operations that would benefit salmon while maintaining these other fish protection measures. Such operations may include intentional flows below what is necessary for mainstem spawning to discourage redds from being established in the area.

Real-time operating decisions will be made through the in-season management process described in Section 9.4. The Technical Management Team will recommend a managed daily average discharge level as information on natural flows and reservoir storage becomes available. The operation for Columbia River mainstem spawning chum salmon will include the following considerations:

- If the operation complies with the conditions described above, it will begin when chum salmon are found in the area around Ives and Pierce islands, but no later than November 1. From November 1 through December 31, FCRPS storage will be used to shape or augment natural flow to a 125 kcfs minimum instantaneous discharge from Bonneville Dam. To prevent spawning in areas that could be subsequently dewatered, the Action Agencies will maintain peak flows within 5 kcfs of the established minimum. For example, if the minimum flow is 125 kcfs, the instantaneous maximum would be 130 kcfs.
- NMFS recognizes that access to spawning habitat in the Ives Island area is primarily a function of the water surface elevation in the Ives Island and Pierce Island areas. Water surface elevation, in turn, is influenced by tides, flow of the Willamette River and discharge from Bonneville Dam. If the established managed discharge cannot be maintained on an instantaneous basis (e.g., during a low spring tide), the Action Agencies will manage FCRPS operations to maintain the water surface elevation in the Ives Island area above the highest redd established by the protection level developed through the in-

season management process. There may be times when this is best accomplished by managing to a Bonneville Dam tailwater gage height rather than to a flow level.

- When reservoir storage, baseflows, and predicted hydrologic conditions permit, a managed instantaneous minimum discharge greater than 125 kcfs may be adopted through coordination with NMFS and the Regional Forum. If such a higher minimum discharge is adopted, the Action Agencies will manage storage with natural flow to provide peak flows within 5 kcfs of the established minimum.
- During incubation and emergence (January 1 through the start of the spring flow augmentation program for the lower Columbia River on April 10), the Action Agencies will manage storage with natural flows to maintain the daily minimum discharge from Bonneville Dam or the adequate water surface elevation needed to protect the highest redd established by the operation and to maintain connectivity between spawning habitat and the mainstem for outmigrants. For example, if the highest redd established by the spawning operation was at an elevation corresponding to a Bonneville outflow of 125 kcfs, a discharge of at least 125 kcfs would be maintained through incubation and emergence. For all managed spawning flows 135 kcfs and above, the highest spawning flow minus 10 kcfs will be the managed minimum discharge during incubation and emergence. The highest managed daily average discharge that will be provided during the incubation and emergence period is 150 kcfs.

A restriction of a 5 kcfs flow range below Bonneville Dam may not be possible at all times. Hydropower operators have shaped flows to nighttime hours to keep spawning below targeted elevations in the mid-Columbia River. This shaping of flows (reverse load factoring) has proved effective in managing the elevations at which fall chinook salmon spawning occurs. However, the effect of shaping nighttime flows on limiting the spawning behavior of chum salmon has not been documented. To the extent that exceedances of the 5 kcfs range are unavoidable, night exceedances are preferable to day exceedances. Evaluation of the effect of shaping higher flows to nighttime hours on chum spawning behavior should be conducted. The Action Agencies should evaluate the effect when nighttime flows exceed the recommended flow range until such effects are better documented.

Several states noted that fluctuations in discharge from Bonneville Dam result in stranding of juveniles in the Ives Island complex. The extent and effect of these flow fluctuations is being assessed through an ongoing research program, and a preliminary recommendation for a ramping rate has been proposed. Continued evaluation of the need for an operation to limit juvenile stranding is required. When adequate information is developed, the appropriate operation shall be specified in the annual and 5-year hydro operations plan.

If in-season data on reservoir elevations and forecasted inflow indicate that operating FCRPS storage reservoirs to provide the flows specified above during chum incubation and emergence would jeopardize the ability to meet RPA items above and/or the ability of parties to comply

with the Vernita Bar agreement, the instantaneous minimum Bonneville outflow will be reduced as necessary to meet these requirements. The Action Agencies will ensure that flow reductions are coordinated through the Technical Management Team to ensure that adverse effects are minimized and to facilitate the development of emergency actions.

The provision of flow to support chum spawning creates a need to provide continual flow through the FCRPS to maintain the redds established below Bonneville Dam during the managed spawning operation. Hydrosystem modeling results suggest that conflicts will occasionally arise between providing the quantity of flow required to maintain established redds and the need to reduce discharge from Grand Coulee to achieve refill to the spring upper rule curve elevation. This potential conflict will be resolved on an annual basis. In general, achieving upper rule curve elevation by April 10 will be a higher priority.

Several states expressed concern that the flows being provided during the chum operation were minimal. Conversely, the Tribes commented that a flow of 125 kcfs is all that should be provided. NMFS maintains that an incremental approach of starting flows at 125 kcfs and increasing them as local base flows rise with seasonal precipitation is reasonable. This management approach provides connectivity with tributary spawning habitat, provides a percentage of mainstem spawning habitat, allows spring reservoir management objectives to be met with a high level of confidence, and is consistent with the concept that offsite mitigation can provide significant benefits to the chum population.

Action 16: The Action Agencies shall operate the FCRPS to provide access for chum salmon spawning in Hamilton and Hardy creeks.

During years when there is insufficient water in storage to maintain a mainstem spawning flow of at least 125 kcfs throughout the spawning season, enough flow will be provided during the chum spawning season at times to allow access to tributary creeks. Under these conditions, the Technical Management Team will develop a recommended operation through the in-season management process.

9.6.1.2.2 Planning and Management of Available Water to Support Mainstem Flow and Spill Objectives

Action 17: The Action Agencies shall coordinate with NMFS, USFWS, and the states and Tribes in preseason planning and in-season management of flow and spill operations. This coordination shall occur in the Technical Management Team process (see Section 9.4.2.2).

Flow objectives serve as a guide to manage available water resources during the juvenile and adult migration seasons and to provide a reference for comparing various operational scenarios that may affect inriver migration conditions. They are not hard constraints. Hydrologic conditions and other constraints may preclude meeting these objectives at all times. These

objectives may not represent optimal conditions and, therefore, may be exceeded if that is deemed the optimal use of water resources after considering the effects on all listed species. Likewise, flow augmentation should not be stopped or diminished once a seasonal average is met. Rather, the flow objectives provide general guidance to the Action Agencies and the Technical Management Team, discussed in Section 9.4.2.2, for in-season management considerations. Because water resources are insufficient to meet the fish flow objectives at all times under all conditions, in-season water management will strive to provide the greatest possible biological benefit from the available storage volumes and system flexibility. Although meeting the flow objectives is an important consideration, it is not an end in itself. The flow objectives are but one of many factors to consider when making decisions about river operations to benefit listed fish. The dates indicated in Table 9.6-1 are for planning purposes. Actual timing of flow measures will be determined in-season by the Technical Management Team.

The Action Agencies have multiple responsibilities affecting hydrosystem operations, including flood control, power production, protection of anadromous and resident fishes and wildlife, navigation, recreation, and irrigation, among other uses. In making operational decisions to meet other FCRPS project purposes and regulatory requirements, the Action Agencies will take all appropriate actions within their authorities to protect listed salmonids.

Several states and Tribes expressed the belief that flow objectives should be hard constraints and that this biological opinion makes too little progress toward securing the necessary water volumes to meet the flow objectives consistently. NMFS' direction to the Action Agencies is for the FCRPS to be managed with the intent of meeting flow objectives both seasonally and weekly. The volume of water available in any given year reflects both natural precipitation and the management of water held in storage. NMFS encourages the Action Agencies to secure the volumes of water needed from storage to increase the frequency of meeting the objectives and discourages actions that would decrease the likelihood of achieving the objectives. Since the achievement of flow objectives is highly influenced by natural precipitation and runoff, flow objectives cannot be hard constraints. Instead, they often serve as guides for the use of water on a seasonal or weekly basis.

9.6.1.2.3 FCRPS Reservoir Operations to Support Mainstem Objectives

Action 18: The Action Agencies shall operate the FCRPS during the fall and winter months in a manner that achieves refill to April 10 flood control elevations, while meeting project and system minimum flow and flood control constraints before April 10. During the spring, the Action Agencies shall operate the FCRPS to meet the flow objectives and refill the storage reservoirs (Albeni Falls, Dworshak, Grand Coulee, Hungry Horse, and Libby) by approximately June 30.

If both these objectives cannot be achieved, the Technical Management Team will make an in-season decision, weighing considerations unique to each particular year. Because research results indicate that flow augmentation has more direct survival benefits for summer than spring

migrants, modest reductions in spring flows to facilitate reservoir refill would generally be preferable to refill failure.

Operating the storage reservoirs to their upper (flood control) rule curve by April 10 will provide a more natural hydrograph and will increase the likelihood that spring flow objectives will be met and reservoirs refilled by June 30. Having reservoirs full on or about June 30, when natural runoff declines, results in the greatest amount of water available for the summer migration period. NMFS recognizes that meeting these flow objectives while refilling reservoirs may not be possible every year, particularly in low water years.

Interruptions or adjustments in water management actions may occur due to unforeseeable power system, flood control, or other emergencies. Such emergency actions should be viewed by the Action Agencies as a last resort and should not be used in place of the long-term investments necessary to allow full, uninterrupted implementation of the required reservoir operations while maintaining other project purposes, such as an adequate and reliable power system.

During winter power system emergencies, water being held in reservoirs for spring and summer flow augmentation may be drafted. Once the emergency is resolved, any flow augmentation water that was used should be replaced as soon as possible, to the maximum extent. During summer emergencies, storage reservoirs may be drafted below biological opinion draft limits, or bypass spill for fish may be reduced.

Discussion of emergencies with effects of exceptional magnitude or duration should include involvement of regional executives. Section 9.4.2.2 provides for the development of more specific process modifications to address these needs in the water management plans.

Action 19: The Action Agencies shall operate specific FCRPS projects as follows:

Hungry Horse Dam. The Action Agencies shall implement VARQ (Corps 1999d) as a flood control operational strategy by January 1, 2001, and upon completion of coordination with appropriate Canadian entities. Under the 1995 NMFS Biological Opinion, the Action Agencies limited fall and winter reservoir drafts to try to achieve a 75% probability of being at the flood control rule curve elevation by April 10 of each year. NMFS acknowledges the chances of achieving a 75% probability of refill to April 10 flood control elevation will be reduced with implementation of VARQ and higher minimum flows for bull trout. Based on hydrosystem modeling results, the probability is approximately 60% of being at the flood control rule curve elevation by April 10 of each year.

Hungry Horse Reservoir may refill later than the June 30 objective, e.g., early July, if necessary to avoid spill that would exceed the state water quality standard for TDG. BOR shall develop a powerhouse maintenance plan to provide full powerhouse capacity to ensure that the project refills in a timely manner without spill that causes TDG to exceed the state water quality standard.

As called for in the USFWS 2000 Biological Opinion, the Hungry Horse minimum outflow shall be determined monthly based on the official volume inflow forecast for Hungry Horse Reservoir for the April through August period as follows. When the April through August runoff forecast is greater than 1,790 kaf, the minimum flow shall be 900 cfs. When the forecast is less than 1,190 kaf, the minimum flow may be reduced to 400 cfs. When the monthly forecast is between 1,190 and 1,790 kaf, the minimum flow shall be determined by linear interpolation between 400 and 900 cfs. The minimum flow in the South Fork Flathead River can be lowered to the physical limit of 145 cfs when the river reaches flood stage at Columbia Falls (13 feet msl).

The minimum flow requirement of 3,500 cfs at Columbia Falls shall be adjusted similarly to between 3,200 and 3,500 cfs based on monthly runoff forecasts. Specifically, when the April through August runoff forecast for Hungry Horse is greater than 1,790 kaf, the minimum flow shall be 3,500 cfs. When the forecast is less than 1,190 kaf, the minimum flow may be reduced to 3,200 cfs. When the monthly forecast is between 1,190 and 1,790 kaf, the minimum flow shall be determined by linear interpolation between 3,200 and 3,500 cfs. These adjustments in minimum flows are necessary to balance the benefits of flow protection for bull trout in the South Fork Flathead River below the dam with reservoir refill and associated biological benefits in the Flathead and Columbia River systems.

The Action Agencies shall limit the reservoir draft to elevation 3,540 feet by August 31 for salmon flow augmentation. BOR shall coordinate drafts for salmon with NMFS, USFWS, the Action Agencies, and other entities through the in-season management process. As a guideline for salmon flow augmentation releases during July and August, Hungry Horse may be operated in a manner that reduces impacts to other listed species while also releasing water to meet salmon flow objectives. Reduction in a second flow peak operation may be achieved by discharging water earlier, or at a more constant rate, to provide the full volume available for salmon.

Libby Dam. The Action Agencies shall implement VARQ (Corps 1999d) as a flood control operations strategy by October 1, 2001, and upon completion of coordination with appropriate Canadian entities. The 1995 NMFS Biological Opinion required the Action Agencies to limit fall and winter reservoir drafts to achieve a 75% probability of being at the flood control rule curve elevation by April 10. NMFS acknowledges that the chances of achieving a 75% probability of refill to April 10 flood control elevation will be reduced with implementation of VARQ and minimum flows for bull trout. Based on hydrosystem modeling results, the probability is approximately 40% of being at the flood control rule curve elevation by April 10 of each year.

Libby may refill later than the June 30 objective, e.g., early July, if necessary to avoid spill that would exceed the state water quality standard for TDG. The Action Agencies shall limit the reservoir draft to elevation 2,439 feet by August 31 for salmon flow augmentation. The Corps shall coordinate drafts for salmon with NMFS, USFWS, the Action Agencies, and other entities through the in-season management process. If Libby is below elevation 2,439 feet on July 1, the Action Agencies shall provide the USFWS bull trout minimum flow or inflow during the July

and August salmon flow season. If this operation results in Libby storing above elevation 2,439 feet in July or August, that storage may be used for salmon flow augmentation before August 31.

As a guideline for salmon flow augmentation releases during July and August, Libby may be operated in a manner that reduces impacts to other listed species, while releasing water to meet salmon flow objectives. Reduction in a second peak operation can be achieved by implementation of a Canadian storage/Libby exchange of water or by releasing water earlier. However, operational flexibility should be retained to release water during the salmon flow season when fish timing or achievement of flow objectives warrant. This operation shall be consistent with winter/spring flood control needs and remaining on minimum or flood control flow during January through April.

Albeni Falls Dam. The action agencies shall continue the lake draw-up, kokanee egg-to-fry survival study at Lake Pend Oreille for the next 6 years. The evaluation shall begin in 2001 by drafting the lake to a fall/winter water level of elevation 2,051 feet. This operation is intended to allow winter storms to improve spawning gravel for kokanee along the shore of Lake Pend Oreille. During the fall/winter of 2002, the Corps shall maintain Lake Pend Oreille at elevation 2,055 feet until fry emerge from shoreline gravels.

By September 2003, USFWS shall secure independent scientific review involving the appropriate frequency of the lake draw up operation, i.e., from 1 to 3 years of draw up. Based on the findings of the independent scientific review of this evaluation, USFWS and NMFS shall provide written recommendations to the Action Agencies concerning fall/winter operations for the 2003 through 2006 period. During this 6-year evaluation period, the Action Agencies shall evaluate the effects of draw-up operations on all life stages of kokanee in Lake Pend Oreille and on predator-prey dynamics.

If, in September 2007, it is determined that lake level management above elevation 2,051 feet effectively improves kokanee production as bull trout forage, USFWS shall provide written recommendations on the frequency of Lake Pend Oreille draw-up for the remainder of this biological opinion.

Grand Coulee Dam. The Action Agencies shall implement VARQ as part of the system flood control operation as noted above at Hungry Horse and Libby. The Action Agencies shall limit fall and winter reservoir drafts to achieve an 85% probability of being at the flood control rule curve elevation by April 10. Grand Coulee may refill by July 4 if flow augmentation to meet flow objectives is not needed until after July 4. The Action Agencies shall draft the reservoir as needed to meet the summer flow objective at McNary Dam. Based on the July final April-to-August runoff volume forecast at The Dalles Dam, the Action Agencies shall limit the reservoir draft to the following end-of-August elevations: 1,280 feet in years when the forecast for The Dalles equals or exceeds 92 Maf and 1,278 feet in years when the forecast is less than 92 Maf.

Dworshak Dam. The Action Agencies shall attempt to refill the reservoir by June 30, while coordinating with the Technical Management Team to meet the spring flow objectives. The Action Agencies shall limit reservoir drafts to elevation 1,520 feet by August 31 to benefit the summer juvenile fish migration. The Action Agencies shall manage Dworshak discharge to attempt to maintain water temperatures at the Lower Granite Reservoir forebay dissolved gas monitoring station at or below 68°F (20°C). To facilitate refill and storage for next year's salmon operations, the Action Agencies shall discharge the established minimum one-turbine flow (about 1,500 cfs at present) following fisheries operations, unless higher flows are required for flood control purposes.

The Nez Perce Tribe expressed a concern that releasing cold water from Dworshak could inhibit the growth rate of wild fall chinook salmon in the Clearwater River. NMFS has attempted to manage the risks to these fish in recent years in its recommended summer flow and temperature operations at Dworshak Dam.

Action 20: The Corps shall operate the lower Snake River reservoirs within 1 foot of MOP from approximately April 3 until small numbers of juvenile migrants are present and shall operate the John Day pool within a 1½-foot range of the minimum level that provides irrigation pumping from April 10 to September 30.

The date for implementing MOP conditions may be delayed at the request of the Technical Management Team to facilitate drafting the pools to MOP to increase discharge at Snake River projects when such increased flows would be more beneficial to juvenile fish. Lower pools reduce the cross-sectional area, increasing water velocity at a given flow. Because juvenile migrants travel faster with increased water velocities, drawdown to MOP is expected to provide faster emigration and improved survival (NMFS 2000h).

Filling the lower three pools enables adult fishways to operate closer to the gate depth criteria of 8 feet at Lower Monumental Dam, 6 to 7 feet at Little Goose Dam, and 7 to 8 feet at Lower Granite Dam. However, recent information indicates that adult salmon pass the Snake River projects readily with gate depths lower than 7 feet (5.5 to 7 feet; low flows and low turbidity generally provide decreased passage times for adult migrants) (Blankenship and Mendel 1997, Bjornn et al. 1998). The effect of this operation will be evaluated during 2000 by the ongoing 2000 radio tracking study. A recommendation for refill of the lower three pools will be developed and included in the annual planning. This will include consideration of study results associated with fish passage. Lower Granite Dam should not be refilled until enough natural cooling has occurred in the fall, generally after October 1.

Action 21: The Corps shall routinely identify opportunities to shift system flood control evacuation volumes from Brownlee and Dworshak reservoirs to Lake Roosevelt and identify such opportunities for the Technical Management Team. The Corps shall implement flood control shifts as necessary to best protect listed fish, as

called for by NMFS in coordination with the Technical Management Team, taking into account water quality issues and the concerns of all interested parties.

Flood control shifts afford an opportunity to increase the frequency of meeting Snake River spring flow objectives while only slightly affecting mid-Columbia River flow conditions. Lesser flood control drafts would occur at Brownlee and Dworshak through March, affording an opportunity to increase flows in the Snake River during April.

Action 22: The Corps and BOR shall implement VARQ flood control operations, as defined by the Corps (1999d), at Libby by October 1, 2001, and at Hungry Horse by January 1, 2001. By February 1, 2001, the Corps shall develop a schedule to complete all disclosures, NEPA compliance, and Canadian coordination necessary to implement VARQ flood control at Libby.

VARQ reduces system flood control drafts at Libby and Hungry Horse reservoirs in years when flood control risks are moderate (average to below-average water years) and adds about 10,000 cfs to summer flows at McNary Dam without increasing flood risks. Impacts to power, flood control, and environmental conditions in Canada have not been fully identified and coordinated. The VARQ concept is a change in system flood control developed by the Corps (1991, 1995, 1997, and 1999d) in response to NWPPC's 1984 Fish and Wildlife Program (NWPPC 1984), the 1995 FCRPS Biological Opinion, and requirements for Kootenai River sturgeon and bull trout imposed by USFWS (1995, 2000a). Conformance with these biological opinions resulted in discharges from Libby Dam during the annual reservoir refill period that far exceeded those envisioned in existing flood control operating plans. These fishery operations can reduce the likelihood and frequency of refill, adversely affecting the availability of augmentation water. NMFS' 1995 Biological Opinion also required the Corps to carefully evaluate system flood control operations. The VARQ concept responds to all these biological opinion requirements.

Hungry Horse can be operated to store up to 400 kaf more water in the spring, and Libby can store up to 1.5 Maf more under VARQ than under current constraints. Local flood control and other effects are small. These operations will increase flow levels in the lower Columbia River and the frequency of achieving the flow objectives by improving conditions for migration.

Whereas many interested parties are aware of this potential operation, implementing VARQ flood control will require additional coordination with Canada, as well as environmental compliance.

Several states did not support the adoption of VARQ during fall spawning periods as a flood control measure due to concerns that it would decrease flows below Bonneville Dam. NMFS' assessment is that VARQ will have a negligible effect on the provision of spawning flows below Bonneville. The draft limit for the Libby Reservoir's end-of-December elevation does not change under VARQ. The end-of-December draft limit for Hungry Horse does change, but

operation of this reservoir in the fall is typically driven by meeting Columbia Falls minimum flows, which usually results in lower elevations than December flood control.

9.6.1.2.4 BOR Non-FCRPS Project Operations to Support Mainstem Flow Objectives

Action 23: BOR shall operate Banks Lake at an elevation 5 feet from full during August by reducing the volume of water pumped from Lake Roosevelt into Banks Lake by about 130 kaf during this time.

Banks Lake is a 27-mile-long equalizing reservoir for the Grand Coulee pump-generating plant. It also provides water to irrigate 672,000 acres of Columbia Basin Project lands. Banks Lake has an active storage capacity of 715,000 acre-feet. BOR indicates that the 130-kaf volume contained in the top 5 feet of Banks Lake storage (i.e., within its normal operating range) could be used to augment Columbia River flows during the summer migration period. This would be accomplished by reducing the volume of water pumped into Banks Lake from Lake Roosevelt and drafting it directly from Lake Roosevelt.

9.6.1.2.5 Non-Federal Project Operations Coordinated with FCRPS and BOR Projects to Support Mainstem Flow Objectives

Action 24: BPA and the Corps shall continue to request and negotiate agreements to annually provide 1 Maf of Treaty storage from January through April 15, release the water during the migration season, and seek additional storage amounts.

Action 25: BPA and the Corps shall continue to request, and negotiate with BC Hydro for storage of water in non-Treaty storage space during the spring for subsequent release in July and August for flow enhancement, as long as operations forecasts indicate that water stored in the spring can be released in July and August.

Flow objectives are met infrequently during the summer months in the lower Columbia River. Storing water during the spring runoff for release during the summer months increases the frequency of meeting the summer flow objectives.

Action 26: BPA and the Corps shall continue to evaluate, request, and negotiate with BC Hydro the shaping and release of water behind Canadian Treaty storage projects in addition to the non-Treaty storage water previously discussed during July and August.

This action may result in examination of various operational or configuration options for achieving this objective. Although not the only option, one long-term possibility for achieving this objective is installation of additional turbines in the powerhouses at Mica and Revelstoke dams. Once the side effects of these installations are addressed, flows could be shifted from

other time periods and be increased by up to 20 kcfs during the months of July and August without the need to spill from these projects.

Several states and Tribes believed the installation of turbines in Canadian projects should be a requirement in the biological opinion. These projects are operated by Canadian entities that are not subject to this biological opinion. Canada's acceptance of this proposal will require the Canadian government to address local issues that will impact the outcome of the turbine discussions.

9.6.1.2.6 Measures to Evaluate and Adjust the Amount of Water Available to Support Flow Objectives

BOR Projects Basinwide. BOR projects operating in the Columbia River basin contribute to streamflow depletions in the Columbia River during the juvenile salmon outmigration season. These depletions decrease the frequency of achieving flow objectives needed to protect migrating juveniles. The following measures specify actions within BOR's authority to reduce streamflow depletions at its projects.

Action 27: Before entering into any agreement to commit currently uncontracted water or storage space in any of its reservoirs covered by this biological opinion to any other use than salmon flow augmentation, BOR shall consult with NMFS under ESA Section 7(a)(2). Such consultations shall identify the amount of discretionary storage or water being sought, the current probability of such storage or water being available for salmon flow augmentation, and any plan to replace the storage volume currently available to salmon flow augmentation that would be lost as a result of the proposed commitment. Also, BOR shall consult with NMFS before entering into any new contract or contract amendment to increase the authorized acreage served by any irrigation district receiving BOR-supplied water. NMFS' criterion in conducting such reviews is to ensure that there be zero net impact from any such BOR commitment on the ability to meet the seasonal flow objectives established in this biological opinion. Replacement supplies should have at least an equal probability of being available for salmon flow augmentation as the storage space or water that is being committed.

Given that current rates of water deliveries adversely affect survival conditions in the migration corridor, further depletions should be avoided until recovery is achieved.

Action 28: BOR shall pursue water conservation improvements at its projects and shall use all mechanisms available to it under state and Federal law to ensure that a reasonable portion of any water conserved will benefit listed species.

This action item is aimed at developing cooperative mechanisms to put more water in the mainstem Columbia River during the juvenile salmon migration season (April through August).

Water conservation is one mechanism that can reduce total diversions and consumption without adversely affecting agricultural production. To be valuable to listed fish, water conservation must result in increased stream flow. Accomplishing this task will require the cooperation of water users and the exploration of opportunities under state law to protect such water from diminution.

Action 29: Within 2 years from the date this opinion is signed, BOR shall provide NMFS with a detailed progress report addressing possible instances where BOR-supplied water within the Columbia River basin is being used without apparent BOR authorization to irrigate lands. In the report, BOR shall indicate how it shall proceed to identify and address instances of unauthorized use.

Federal agencies are required to consult only on actions that are “authorized, funded, or carried out by such agency[.]” 16 U.S.C. Section 1536(a)(2). NMFS recognizes that unauthorized uses of BOR-supplied water are by definition not “authorized, funded, or carried out” by BOR. As BOR works within the limits of its authority to address any identified episode of unauthorized use of BOR-supplied water, NMFS recognizes that, in some instances, BOR will have to take contract actions and consult on them. Accordingly, in action item 27 above, NMFS set out how those consultations will proceed. This reporting requirement will help all parties understand the nature and extent of actual unauthorized use.

Action 30: For those BOR projects located in the Columbia River and its tributaries downstream from Chief Joseph Dam (Table 9.6-2), BOR shall, as appropriate, work with NMFS in a timely manner to complete supplemental, project-specific consultations. These supplemental consultations shall address effects on tributary habitat and tributary water quality, as well as direct effects on salmon survival (e.g., impingement, entrainment in diversions, false attraction to return flows, and others). These supplemental consultations shall address effects on mainstem flows only to the extent to which they reveal additional effects on the in-stream flow regime not considered in this biological opinion (e.g., flood control).

This biological opinion considered the likely effects of BOR’s Columbia River basin irrigation projects on flow conditions in the mainstem Columbia River migration corridor. Other effects, such as tributary habitat, fish passage and entrainment, and water quality, have not been evaluated in this biological opinion. To further the intensive approach defined in this RPA, timely consideration of such effects and, if necessary, development and implementation of measures to avoid, minimize, or mitigate them are needed. Supplemental consultations for several of these projects are currently underway (e.g., the Yakima Project and Umatilla). These overarching needs are further defined in the project-specific measures identified in Table 9.6-2.

Columbia Basin Project. Grand Coulee Dam, which is an integral component of the Columbia Basin Project, is also one of the specific FCRPS projects addressed in Section 9.6.1.2.3. Because the Columbia Basin Project diverts water from and returns it to the mainstem Columbia River

above McNary Dam, its storage and diversion operations are not easily separated from the other operations at Grand Coulee.

Table 9.6-2. BOR projects in the Columbia River basin subject to supplemental consultations.

Project	Location	Subbasin or Stream
<i>Upper Columbia River (Upstream of Snake River Confluence)</i>		
Chief Joseph ¹	North-central Washington, from Canadian border to Wenatchee	Okanogan and Columbia rivers
Okanogan	North-central Washington, near Okanogan	Okanogan River
Yakima	Central Washington, near Yakima	Yakima River
<i>Lower Columbia (Downstream of the Snake River Confluence)</i>		
Umatilla	Northeast Oregon	Umatilla and Columbia rivers
Crescent Lake	Central Oregon west of Bend	Deschutes River
Crooked River	Central Oregon, north of Bend	Crooked River
Deschutes	Central Oregon, north of Bend	Deschutes River
Wapinitia	North-central Oregon, south of The Dalles	Deschutes River
The Dalles ¹	North-central Oregon, near The Dalles	Columbia River
Tualatin	Northwest Oregon, west of Portland	Tualatin River (Willamette River)

¹ This table identifies irrigation works BOR owns and operates. The Corps owns and operates Chief Joseph Dam and its powerhouse and The Dalles Dam and its powerhouse.

Action 31: BOR shall assess the likely environmental effects of operating Banks Lake up to 10 feet down from full pool during August. The assessment and NEPA compliance work shall be completed by June 2002 to determine future operations at this project by the summer of 2002.

An additional 130 kaf could be obtained from Banks Lake storage if the project is not filled 5 more feet using Grand Coulee storage, resulting in a total draft of 10 feet from full pool, during the summer. This would provide a total flow augmentation volume of about 260 kaf from Banks Lake. Because this total draft is beyond the normal project operating range, however, BOR will have to conduct a formal study and NEPA compliance review on this action before implementation.

BOR Upper Snake Projects and IPC Hells Canyon Complex

Action 32: The Action Agencies shall acquire water for instream use from BOR's Upper Snake River basin projects and Idaho Power Company's Hells Canyon Complex during the spring and summer flow augmentation periods to improve the likelihood of achieving spring and summer flow objectives at Lower Granite Dam.

Ongoing Section 7 consultations with BOR on the Upper Snake projects and with FERC and the Idaho Power Company on the Hells Canyon Complex will consider the need for releases of water or other operations at these projects to address their effects on listed Snake River salmon and steelhead. Upon completion of these consultations and related biological opinions, and to the extent additional water or operating flexibility is available, the Action Agencies will pursue acquisition of such additional water from willing sellers or operating flexibility as offsite mitigation for the effects of the FCRPS projects. Such additional water or operating flexibility would be used to improve the ability to achieve the Snake River flow objectives identified in Table 9.6-1.

Dworshak Hatchery and Reservoir Operations

Action 33: The Corps, in coordination with USFWS, shall design and implement appropriate repairs and modifications to provide water supply temperatures for the Dworshak National Fish Hatchery that are conducive to fish health and growth, while allowing variable discharges of cold water from Dworshak Reservoir to mitigate adverse temperature effects on salmon downstream in the lower Snake River.

The rationale for providing improvements to the hatchery water supply is to isolate the effect of Dworshak Reservoir operations on Snake River temperature control from the effect of hatchery operations. At present, Dworshak Reservoir cannot be operated for optimal temperature releases because of adverse effects on hatchery rearing performance. This problem would be resolved by making improvements in the hatchery water supply system to accommodate releases of cooler water from Dworshak to benefit salmonid migrants and water quality in the lower Snake River.

Action 34: The Action Agencies shall evaluate potential benefits to adult Snake River steelhead and fall chinook salmon passage by drafting Dworshak Reservoir to elevation 1,500 feet in September. An evaluation of the temperature effects and adult migration behavior should accompany a draft of Dworshak Reservoir substantially below elevation 1,520 feet.

The rationale for evaluating an additional 20-foot draft of Dworshak Reservoir in September is to determine whether cooling Snake River temperatures during September would provide an adult passage benefit. The potential benefits are 1) reduction in water temperature, 2) possible elimination of a thermal block that delays adult migration into and through the lower Snake River, and 3) improved gamete viability. An evaluation should be conducted to assess the effects of the September draft on lower Snake River temperatures and on the migratory behavior and passage timing of adult salmonids that are equipped with depth and temperature-sensitive tags. An evaluation of Dworshak refill probability indicates that this study operation would have little impact on reservoir refill by the end of June in the following year, i.e., two additional refill misses in BPA's 50-year hydrosystem study.

Flood Control Assessment

Action 35: The Corps shall develop and conduct a detailed feasibility analysis of modifying current system flood control operations to benefit the Columbia River ecosystem, including salmon. The Corps shall consult with all interested state, Federal, Tribal, and Canadian agencies in developing its analysis. Within 6 months after receiving funding, the Corps shall provide a feasibility analysis study plan for review to NMFS and all interested agencies, including a peer-review panel (at least three independent reviewers, acceptable to NMFS, with expertise in water management, flood control, or Columbia River basin anadromous salmonids). A final study plan shall be provided to NMFS and all interested agencies 4 months after submitting the draft plan for review. The Corps shall provide a draft feasibility analysis to all interested agencies, NMFS, and the peer-review panel by September 2005.

The primary objectives of this feasibility analysis will include reducing the effects of flood control operations on the spring freshet, particularly during average to below-average runoff years; minimizing flow fluctuations during fall chinook emergence and rearing; and achieving a high probability of reservoir refill, particularly at Dworshak, Grand Coulee, Hungry Horse, and Libby reservoirs, while maintaining acceptable levels of protection for developed areas within the active floodplain. This analysis will consider all aspects of flood control, including the flood control target flow(s), associated storage reservation diagrams, the method of calculating the initial control flow, and the timing and coordination of flood control management. The study will incorporate the best currently available forecast technology for estimating runoff and peak flows. Innovative concepts, such as using an expert system to define operations in real time, that would increase system flexibility or the ability to achieve the above stated objectives should be incorporated to the extent practical. New storage reservation diagrams should include mechanisms for interpolation to facilitate higher storage contents going into the spring in some years. The Corps will also identify those improvements necessary to facilitate higher flood control target flows and estimate the cost and time needed to implement such improvements.

This analysis will include all Federal, non-Federal, and Canadian projects currently operated for system flood control. Because modifying flood control operations would affect an array of interests, the Corps should consult with all interested state, Federal, Tribal, and Canadian agencies in developing its analysis. The final feasibility report will include a proposed action and respond to all concerns and comments on the draft.

System flood control strongly influences streamflow characteristics in the mainstem Snake and Columbia rivers. As described in Section 6 of this biological opinion, these hydrologic effects affect juvenile salmon survival. While current flood control operations routinely reduce even non-damaging floods, peak flows of historical magnitude (e.g., the 1948 Vanport flood) would result in substantial damage. The intent of this study is to refine flood control operations such that they cause the least possible reduction in runoff volumes and the probability of reservoir

refill while maintaining high levels of protection from damaging floods. Preliminary analysis of modifying system flood control showed that potentially much higher spring flows were possible (Corps 1997) in some years.

Much of the existing flood control operation plan dates to the 1960s, and a systematic review of flood control operations has not occurred since 1991. That study, however, was based on the fundamental premise *“that the existing flood control capability ...would remain unchanged after any rule curve modifications were made (Corps 1991).”* Thus, *“...it is conceivable that flood control criteria could be reduced substantially, and levees raised a corresponding amount to compensate.”* A broader consideration of flood control options could identify operations that would benefit the fishery without increasing the likelihood of damaging floods.

New streamflow prediction techniques, including extended streamflow prediction (ESP) (NOAA River Forecast Center streamflow model) and remote sensing, have greatly improved since 1969. Computer improvements facilitate consideration of a broader range of alternatives and the ability to manage flood risks more closely to a real-time basis. A thorough investigation of new forecasting technologies would enhance system response and afford greater precision in system flood control operations.

Furthermore, flood control concepts are changing. Historically, efforts were made to protect all developed lands from flooding by using levees, revetments, and upstream storage. These efforts have effectively disconnected rivers from their floodplains and have had both ecological and human consequences (Benner and Sedell 1997). Ecologically, diverse and integral habitats are lost when structures isolate a river from its floodplain (Ligon et al. 1995, Corps 2000b). Riparian corridor simplification is a significant cause of salmon declines (Ligon et al. 1995, Corps 2000b). Also, by cutting off upstream floodplains from the river, vast flood storage potential is lost, and floodplain development is encouraged. Thus, when large floods occur, the outcomes in terms of property damage can be more severe than would have occurred if lesser flood protection efforts had been taken and floodplain development discouraged. By examining flood damage areas and flood protection structures throughout the river corridor, the Corps may identify opportunities to bring more connectivity to some areas of active floodplain (e.g., undeveloped land and farmland) and more effective flood protection to others (e.g., communities).

Libby Operations

Action 36: By October 1, 2002, the Corps shall develop and, if feasible, implement a revised storage reservation diagram for Libby Reservoir that replaces the existing fall draft to a fixed end-of-December elevation. One option is to evaluate variable drafts based on the El Niño Southern Oscillation Index (SOI) predictions or other forecast methodologies of runoff volume. To implement this change, the Corps shall complete successful coordination with Canada under the Columbia River Treaty.

Currently, a fall draft at this project is aimed at reaching a fixed end-of-December elevation to ensure that, given other project constraints, enough water can be evacuated to achieve desired levels by the end of April in all years. If lesser drafts were made, it could be difficult to achieve desired reservoir levels in the wetter years. Traditional snow-water surveys are not available until January, so Libby is drafted each year in the fall, assuming a wet-year condition. In low water years, this can result in drafts below the subsequent April 30 upper rule curve elevation (end of storage evacuation season) and result in the project being unable to refill by the end of June. Under current operating criteria, hydrosystem regulation studies (BPA 2000b) show that Lake Koocanusa does not achieve the 75% probability of refill proposed by the Corps in the biological assessment (BPA et al. 1999). These excessive drafts can increase the streamflow attenuation needed to achieve refill in the spring and reduce the probability of refill, placing additional risks on listed fish, particularly in the driest years when increasing discharge would be most valuable.

Recent advances in climatology have resulted in predictive tools that roughly estimate Pacific Northwest runoff volumes from meteorological conditions in the southern Pacific. The Corps has adopted an SOI-based runoff model as the best available forecast for Dworshak that uses this forecast to define Dworshak drafts from January through April. The Corps is investigating the use of a similar runoff model for Libby Dam. The Corps is also investigating operational changes that could alleviate the reason for avoiding all spills at Libby Dam, which is a contributing factor in the current fixed end-of-December reservoir draft. This action would expand the use of a SOI-based or a similar runoff prediction method into the fall at Libby Dam and could result in revision of the storage reservation diagram to allow reduced drafts in average-to-dry years.

9.6.1.2.7 Actions to Address Columbia Basin Project Effects Other than Flow Depletions and Storage Operations. Certain facilities and operations at the Columbia Basin Project present risks to listed salmon and steelhead other than those associated with mainstem flows. BOR will investigate the effects of these facilities and operations. Where adverse effects on listed salmon or steelhead are found, BOR will develop measures to avoid or minimize such effects in consultation with NMFS.

Action 37: BOR shall investigate the attraction of listed salmon and steelhead into wasteways and natural streams receiving waste water from the Columbia Basin Project. If listed fish are found to be attracted into these channels, BOR shall work with NMFS to identify and implement structural or operational measures to avoid or minimize such use, as warranted.

Action 38: By March 1, 2002, BOR shall install screens meeting NMFS' screen criteria at the canal intakes to the Burbank No. 2 and Burbank No. 3 pump plants. BOR shall connect the Burbank No. 3 intake canal to Burbank Slough to provide juvenile fish egress. BOR shall coordinate with NMFS on each of the actions identified above.

Action 39: BOR shall evaluate the water quality characteristics of each point of surface return flows from the Columbia Basin Project to the Columbia River and estimate the effects these return flows may have on listed fish in the Columbia River and in the wasteways accessible to listed fish. By June 1, 2001, BOR shall provide NMFS with a detailed water quality monitoring plan, including a list of water quality parameters to be evaluated. If the water quality sampling reveals enough water quality degradation to adversely affect listed fish, BOR shall develop and initiate implementation of a wasteway water quality remediation plan within 12 months of the completion of the monitoring program.

Return flows from BOR's Columbia Basin Project may reduce water quality in the Columbia River and may adversely affect aquatic life and listed salmon. Because of the potential for adverse effects on listed fish, detailed water quality monitoring and analysis are needed to define these water quality effects. Depending on the results of the water quality sampling, BOR should develop and begin implementation of a water quality remediation plan for BOR wasteways within 12 months of completing the water quality monitoring program and include the plan as part of the Action Agencies' annual and 5-year water quality improvement plans. This measure is intended to supplement the MOU between BOR, EPA, the Washington Department of Ecology, and the three Columbia Basin irrigation districts regarding surface water quality protection of the Federal Columbia Basin Project waters. Remediation measures will be consistent with the terms of that agreement to the extent possible.

9.6.1.3 Juvenile Fish Transportation

9.6.1.3.1 Strategy. This RPA requires transportation of juvenile salmon and steelhead migrants in spring and summer. During the spring migration, transport is required at Lower Granite, Little Goose, and Lower Monumental dams. During the summer migration, transport is required from the same three Snake River dams and is also required from McNary Dam. Spill is to be provided in accordance with Section 9.6.1.4.4 to provide the highest survival passage route for inriver migrants during the spring months and to provide for research in summer. Except as specifically provided for research, however, all collected fish are to be transported.

The spring transport strategy in this RPA requires both transport and spill at collector projects to spread the risk by ensuring favorable project passage conditions for inriver migrants. There is no attempt to manage to a specific transport/inriver ratio. Estimates of the proportion of SR spring/summer chinook that are expected to be transported under this strategy range from 43% to 91% depending on flow/runoff conditions.

The current strategy reflects a management program based on transportation research conducted to date. However, ongoing research using PIT tag technology will allow a much finer level of resolution to be obtained on the seasonal effects of transportation. The research results will be reviewed annually, and adaptive management changes may be made in the transportation strategy if definitive research results support a change in strategy.

The summer transport strategy is to maximize collection and transportation due to concerns about low inriver survival rates. During the summer, flow is frequently below the biological flow objectives established by NMFS, and water temperature is frequently above the water quality standards established by EPA and the state water quality agencies. As a result, fish spill is curtailed, and all collected fish are transported during the summer to improve overall juvenile fish survival.

The actions in this section are presented as follows:

- Current and near-term actions
- Studies, including research, monitoring, and evaluation
- Future actions

9.6.1.3.2 Current and Near-term Actions

Action 40: The Corps shall continue to transport all non-research juvenile salmonids collected at the Snake River collector projects. The Corps and BPA shall continue to implement voluntary spill at all three Snake River collector projects when seasonal average flows are projected to meet or exceed 85 kcfs.

If new information shows that survival through inriver migration, including returning fish to the river, is beneficial, these data will be reviewed and discussed during the annual planning process. In particular, BPA and the Corps, working with NMFS through the annual planning process, have to consider the scientific basis for the 85-kcfs voluntary spill trigger. Any resulting changes in the annual transport operations will be formalized through the consultation framework or a similar process.

Action 41: The Corps and BPA shall continue (pending results of the McNary Transport Evaluation) to bypass juvenile spring migrants collected at McNary Dam and shall provide the spring spill levels described for that project.

Transport of spring migrants from McNary was suspended in the 1995 FCRPS Biological Opinion (NMFS 1995a) because a review of the data indicated the benefit from transport was uncertain. This moratorium on spring transport from McNary was continued in the 1998 Supplemental FCRPS Biological Opinion (NMFS 1998) because the adult returns of detected PIT-tagged juvenile fish that passed through the McNary bypass system in 1994 were lower than expected. These data suggest there may be an undetected problem with the juvenile bypass system. This issue should be resolved before initiating the McNary spring transport evaluation.

Action 42: The Corps and BPA shall operate the collector projects to maximize collection and transportation during the summer migration (i.e., no voluntary spill except as NMFS deems necessary for approved research).

Past research evaluating fall chinook transport from McNary indicated the highest benefits occur during the summer low flow/warm water temperature periods. The 1982 research (Park et al. 1982) evaluated transport by truck during the early, middle, and late phases of the summer outmigration.

The early control group (June 25 to July 2) was released when daily average river flows were dropping from 444 to 372 kcfs, and water temperature averaged about 60°F (16°C). Based on survival to adulthood, transport yielded no benefit to the early phase (0.9:1).

The middle control group (July 6 to 22) was released when river flows ranged from 358 to 206 kcfs, and water temperatures ranged from 61° to 66°F (16 to 19°C). Based on survival data, there was a minor benefit to the middle phase (1.36:1).

The late control group (July 27 to Aug 5) was released when river flows were dropping from 218 kcfs to 158 kcfs, and water temperatures were 67° to 70°F (19 to 21°C). This group showed the highest transport benefit of 4.6:1. Available data, although limited, did not indicate a benefit from transport of summer migrants during early summer. A similar study was conducted in 1983 (Park et al. 1984), but marking did not begin until July 7 that year so the data were not comparable to the 1982 study. Results, however, showed a positive benefit from both barge and truck transport. Control groups in that study were released when river flows ranged from 169 to 232 kcfs.

Action 43: The Corps shall not initiate collection of subyearling fall chinook for transportation at McNary Dam until inriver migratory conditions are deteriorating (i.e., no longer spring-like).

In general, the switch from spring to summer operation will occur on or about June 20. Each year in the in-season management process, the Technical Management Team has the discretion to recommend a change in transportation operations at McNary Dam earlier or later based on in-season monitoring of inriver conditions. When more favorable spring-like flow and temperatures either end before or extend after the spill planning dates, the actual date to end spill at collector projects, and to initiate transport from McNary, will be modified, continuing to spread the risk of transportation versus inriver passage for spring migrants as long as spring-like river conditions persist.

Spring-like is defined as favorable flow and water temperature conditions; i.e., river flows are at or above the spring flow target (220 to 260 kcfs) at McNary Dam, and ambient water temperatures are below 62°F (17°C).

Action 44: The Corps shall extend the period of barge transportation from the lower Snake River dams and McNary to further reduce reliance on trucking.

Barge transport of spring migrants from the lower Snake River dams was extended approximately 3 weeks in 1998 to partially address regional concerns regarding truck transportation. The Corps has proposed to extend the barging period another 5 weeks (to around the end of July). NMFS views the proposed extension as a first step; however, a further extension is desired. NMFS recognizes that, as a result of prioritizing available O&M funds, a further extension of barging will have to be phased in over a period of years.

9.6.1.3.3 Studies (Including Research, Monitoring, and Evaluations)

Action 45: By the end of 2001, the Corps shall develop, in coordination with NMFS and the other Federal, state, and Tribal salmon managers, a McNary Dam transportation evaluation study plan specifically focusing on the response of UCR spring chinook and steelhead to transportation. Approved research should begin by 2002, if feasible.

Evaluation of spring transport from McNary shall be initiated in 2002, assuming that adult PIT-tag detectors will be installed at selected locations by spring 2002 and pending results of the McNary Dam juvenile fish bypass evaluation. Implementation of such research is a high priority and should serve to accelerate development and installation of adult PIT-tag detection capability in mainstem adult fishways. At a minimum, objectives of the study shall include the following:

- Identification of population and/or genetic composition of test fish
- The absolute return rates of transport and inriver groups
- The ratios of transport to inriver return rates and their relationships to river conditions
- The effects of transportation from McNary on homing
- Relationships between ratios of transport and inriver return rates and measurements of juvenile survival (D values) below McNary Dam

Action 46: The Corps and BPA, in coordination with NMFS through the annual planning process, shall evaluate transport to inriver return ratios for wild SR yearling chinook salmon and steelhead. In addition, the Corps and BPA shall also evaluate the effects of transportation on summer-migrating subyearling SR chinook salmon.

The research methodology currently used to evaluate spring-migrating fish is to mark and release wild fish at Lower Granite Dam and re-collect some of them for transport at Little Goose Dam. An inriver group of marked fish is allowed to continue their migration inriver. This study protocol was selected to handle the fewest wild salmon and to increase the undetected inriver sample group of fish. The existing study design should continue until wild Snake River

anadromous salmonids are abundant enough to conduct studies by PIT-tagging wild fish in natal areas above the lower Snake River dams.

If the decision for the long-term operation of FCRPS projects on the lower Snake River includes continued reliance on transportation, the Corps and BPA will continue transport survival studies for spring and summer migrants passing Lower Granite Dam in future years. Information from these studies will be the basis for modifications to the transportation program to increase salmon survival. Future transportation studies will include the evaluation of modifications made to the transportation system.

NMFS has adopted a spread-the-risk policy for transportation of spring migrants while studies are being conducted to evaluate the effects of the spring transportation program. In contrast, NMFS has chosen to maximize transportation of fall migrants because of the adverse conditions that exist for inriver migrants during the summer season. Historic data have demonstrated a benefit to transportation. Additional research should occur to reassess the effectiveness of transportation under more recent conditions.

The evaluation of summer transport will consist of determining the smolt-to-adult survival of subyearling fall chinook transported from Lower Granite Dam relative to marked study fish left to migrate inriver. This study will require adequate numbers of representative test fish (i.e., Lyons Ferry hatchery stock) and suitable inriver conditions for comparison with transportation. This includes spill at Snake River collector projects to reduce turbine mortality, alternative water management strategies to enhance flows and reduce water temperature, and more intensive predator management. To reduce the risks associated with an incorrect assumption about the effectiveness of either transportation or inriver migration, spill to enhance inriver conditions will be included as a test condition on an alternating annual basis. In this way, outmigrants will be subject both to inriver conditions that include spill at Snake River dams and maximum transport conditions across the duration of this study. The ability to provide summer spill at Snake River dams will require modifications of the electrical transmission system. These upgrades are expected to be completed by 2004. Pending completion of these upgrades, the inclusion of spill would start and would continue for several years. This study will start under current operations beginning in the summer of 2001.

The development of the specific study protocol should be coordinated through the Regional Forum and research processes. The Action Agencies will include these studies in the annual and 5-year hydrosystem plans.

Action 47: During all transport evaluations, the Corps and BPA, in coordination with NMFS through the annual planning process, shall include an evaluation of delayed mortality (D) of transported versus inriver migrating juvenile anadromous salmonids.

Considerable uncertainty exists concerning the levels of differential post-Bonneville Dam mortality of transported and non-transported fish. Evaluations of post-transport and post-bypass delayed mortality are high priorities. The highest priority is determining how much transportation mitigates for the loss of juvenile anadromous salmonids during passage through the hydrosystem. The mechanism for implementing this action (mark and recapture studies) is described in Section 9.6.5.3.5.1.

Action 48: The Corps and BPA shall evaluate the effects of prior transport as smolts on the homing of adults.

Past research was not designed to directly evaluate the effects of transportation on the homing of returning adults. Ancillary data derived from earlier studies suggested that transportation-induced homing impairment was minimal. Studies designed to directly and precisely compare homing capabilities of transported and non-transported fish are needed. This research will require the installation of adult PIT-tag detectors at several dams and hatcheries on the Columbia and Snake rivers.

Action 49: The Corps shall evaluate strategies to enhance post-release survival of transported fish; examples of such strategies include timing releases so that fish arrival at the estuary corresponds to minimal interactions with predators and maximum availability of forage and locating releases so as to decrease passage time through areas of high predation.

No consideration has been given to the timing of fish arrival in the estuary when scheduling fish transport operations. In the past, the preference for release of transported fish was after dark to reduce the potential for predation, but this does not occur on a regular basis. Additional information on spring chinook transported from the Snake River indicates that fish released to arrive at the saltwater interface during the ebb tide move rapidly into the Columbia River plume. Fish that reach the saltwater interface during high tide hold in the estuary and either move upstream in the navigation channels or hold over in the shallow water grassflats. In both cases, salmon are exposed to increased levels of avian predation.

9.6.1.3.4 Future Actions

Action 50: BPA and the Corps shall install necessary adult PIT-tag detectors at appropriate FCRPS projects before the expected return of adult salmon from the 2001 juvenile outmigration.

By October 2000, the Action Agencies will develop a schedule for installing adult PIT-tag detectors at projects by working through the annual planning process and the Regional Forum. The schedule will maximize the ability to conduct research identified in this biological opinion in a timely manner and will address the possibility of installing detectors at Bonneville and McNary dams by 2002. Adult detector installation identified in the annual planning process should be put

in place as soon as possible. If technical problems preclude installation of these adult PIT-tag detectors within this time frame, the evaluation of spring migrant transportation from McNary should be delayed until the detection systems are certain to be installed.

Action 51: If results of Snake River studies indicate that survival of juvenile salmon and steelhead collected and transported during any segment of the juvenile migration (i.e., before May 1) is no better than the survival of juvenile salmon that migrate inriver, the Corps and BPA, in coordination with NMFS through the annual planning process, shall identify and implement appropriate measures to optimize inriver passage at the collector dams during those periods.

Limited available data suggest that juveniles collected and transported early in the spring season do not survive as well as fish that are transported in May and thereafter. It may be that, because they are transported, those fish arrive in the estuary before they are physically prepared to enter saltwater, or alternatively, predator abundance may vary during the early ocean phase in different years. Additional data are needed to help reduce this uncertainty.

Action 52: The Corps shall identify and implement improvements to the transportation program.

Such improvements should include maintenance/upgrade of fish transport trailer chillers before the summer trucking season (as long as trucking continues) and daily transport of juvenile salmon exhibiting signs of *Columnaris* disease during the summer warm-water season, preferably in 5- to 10-ppt saline with minimal handling if transported by truck.

Action 53: The Corps shall evaluate and implement structural and operational alternatives to improve juvenile transportation at the collector dams.

These alternatives could include improvements to the juvenile bypass systems, holding and loading facilities, and construction of smaller barges for use during the summer.

9.6.1.4 Juvenile Fish Passage

The measures described in this section represent the best starting points for planning future capital investment in activities to improve the survival of juvenile salmon migrating past the Corps mainstem FCRPS dams. The specific list of measures to be implemented, their priority, and the method of evaluation will be developed in the 1- and 5-year plans described in Section 9.4. As determined through the annual planning process in Section 9.4, other combinations of measures may also be deemed sufficient to meet the juvenile and adult performance standards and, thus, to avoid jeopardy.

Based on information in the biological effects analysis in Appendix D, Bonneville, The Dalles, and Lower Monumental dams have the lowest juvenile fish passage survival rates in the FCRPS.

For this reason, improvements in juvenile dam passage survival at these mainstem dams should be an area of immediate focus.

Many of the measures described in this section are limited to prototype or facility development and evaluation and include statements that the Action Agencies are expected to implement an action based on study results as warranted. The intent in these cases is to proceed to implementation immediately upon completion of testing, unless the results present problems that have to be addressed through further testing before implementation. The fish passage survival analysis in Section 9.7 assumes that fish passage facility improvements would be implemented, not just tested. As a result, progress in moving from research and development to implementation will be a necessary and integral part of the annual planning and review process, and undue delay may require a reinitiation of consultation.

9.6.1.4.1 Juvenile Fish Passage Strategy. A primary objective of the biological opinion is to increase survival of juvenile outmigrants through the Federal hydrosystem. This objective should be accomplished consistent with two biological principles: 1) protecting biodiversity and 2) favoring fish passage solutions that best fit the natural behavior patterns and river processes (ISAB, 1999). This applies to fish passage through the eight FCRPS hydroelectric projects and their associated reservoirs. The purpose of this fish passage strategy statement is to provide general guidance on dam passage priorities for future annual implementation planning.

Spillway Passage. Spillway passage is the preferred passage method for juvenile salmonids that are not collected and transported. It should be the baseline against which other passage methods are measured. The body of research evidence indicates that juvenile survival is generally highest through this passage route and suggests it can reduce forebay delay. Therefore, measures that increase juvenile fish passage over FCRPS project spillways are the highest priority unless it can be shown that alternative passage improvements would provide comparable survival. This assumes that spillway passage is implemented in a biologically safe manner to maintain appropriate water quality, while ensuring adequate juvenile egress conditions in the tailrace and minimizing effects on adult passage.

Surface Bypass Passage. Surface bypass is defined as a surface-oriented route that provides an appreciable attraction flow-field and discharges juvenile fish directly to the project tailrace. Continued development and testing of surface bypass prototypes at mainstem FCRPS projects should be a high priority. A surface bypass at one or more spill bays, or through a surface bypass next to the spillway or powerhouse, may provide complementary survival benefits for fish that do not pass through a conventional spillway tainter gate. Surface bypass passage is a promising concept that may, with further testing and development, satisfy the intent of increasing safe passage through a high-flow conveyance similar to the spillway. It also has a potential benefit of providing fish passage with incrementally lower spill discharges and lower production of TDG.

Surface Collection Passage. In contrast to surface bypass, surface collection is defined as a surface-oriented route that entails collection at one or more entrances, followed by lateral routing

in a channel that guides fish away from turbine intakes. In this biological opinion, surface collectors are considered to be installed across a portion of, or over the entire upstream face of, the powerhouse at a given site. For fish that do not pass through either spillway or surface bypass routes, this option is expected to provide more natural passage conditions for those that approach the powerhouse. Similar to the surface bypass concept, surface collection is also a promising concept that may, with further testing and development, satisfy the intent of increasing safe passage through a high-flow conveyance. With successful development in the future (including reconciling concerns regarding high discharge outfalls), this option would be preferred to other powerhouse passage options (see below).

Powerhouse Intake Screen and Bypass Systems. Turbine intake screens and bypass systems provide the best protection for those fish that enter turbine intakes (as opposed to passing through other non-turbine routes). Increasing juvenile survival through collection and safe passage using this type of system continues to be a priority at many FCRPS hydro projects. This fish protection system will continue to be the primary powerhouse protection alternative at some projects until either surface bypass or surface collection is fully developed and constructed.

Turbine Passage. The least preferable route of passage for juvenile and adult fish is through turbines, where a generally higher mortality rate occurs due to direct mechanical injuries and adverse pressure changes incurred while passing through the turbine. Further, indirect mortality is likely a significant problem downstream of the powerhouse, where disoriented fish are vulnerable to predation. Efforts described above to reduce turbine passage notwithstanding, it is prudent to continue to research and, where appropriate, implement improved turbine designs that reduce direct and indirect mortality. Additional investigations are necessary to reduce the magnitude of direct and indirect turbine mortality, as well as continued evaluations of recent advances in turbine design such as minimum gap runners.

9.6.1.4.2 Overview of RPA Actions Project-by-Project. The following project-by-project overview is provided for ease of reference so that juvenile passage measures, which are detailed as actions in the following sections, can be viewed and understood from a broader context. This section also describes issues such as decision dates for alternative passage improvements and other considerations that may influence implementation.

Bonneville Dam. The dam passage survival rate at Bonneville Dam is currently one of the lowest of any Corps FCRPS project and is, therefore, the highest priority relative to the need for improvements. Existing spill levels, configurations, and facilities at Bonneville Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- A 24-hour spill; with nighttime spill limited to the TDG cap, and daytime spill limited to 75 kcfs for adult passage
- Standard-length screens at all 18 main units (at both powerhouses)

- A first powerhouse monitoring facility/bypass outfall that releases fish into the immediate tailrace and a new second powerhouse monitoring facility/bypass outfall that releases fish approximately 9,000 feet downstream of the powerhouse
- An ice and trash sluiceway at the first powerhouse
- An 18-bay spillway with deflectors on 13 bays

Bonneville First Powerhouse. The Corps will evaluate surface collector and extended submerged intake screen prototypes in 2000, followed by a decision to proceed with development of one alternative (or a hybrid of each); proceed to design and construction of the most promising option; complete minimum gap turbine runner installation and evaluation; continue to develop debris-control measures; and continue to develop improvements to the existing juvenile fish bypass system (including dewatering screens and outfall relocation).

Bonneville Spillway. The Corps will finish spillway deflector optimization development and implement deflector additions and improvements, develop optimum spill patterns and conduct juvenile survival studies, continue to evaluate adult spillway fallback and implement remedies as warranted, synthesize results to determine how to optimize spillway adult and juvenile project/spillway survival, and implement the most promising measures.

Bonneville Second Powerhouse. The Corps will develop and implement a surface bypass corner collector, pending high-flow outfall investigation results for increasing the high-flow impact velocity criterion, conduct outfall site selection evaluations, and design and construct a corner collector system by 2004 (if exceeding the velocity criterion does not increase juvenile mortality); continue intake screen guidance improvement investigations and implement them as warranted; implement auxiliary water improvement measures; investigate and implement debris control measures; investigate a less intrusive PIT-tag interrogation method for the new juvenile fish bypass system; and implement measures as warranted.

The Dalles Dam. Spill levels, configurations, and facilities at The Dalles Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- A 24-hour spill at 40% of river flow
- An ice and trash sluiceway operated as a surface bypass
- A 23-bay spillway, with a shallow spilling basin and no deflectors

The Corps will evaluate, identify, and implement the appropriate 24-hour spill levels (day and night considered separately) to optimize spring and summer juvenile survival; investigate surface bypass collection efficiency improvements (blocked trash racks) and sluiceway passage survival in 2001 and fully implement measures across the powerhouse as warranted; evaluate the juvenile survival benefit of sluiceway outfall relocation; and implement composite outfall relocation and auxiliary water emergency measures. If the spillway juvenile mortality rate is excessive at 40%

spill in 2000, the Corps will investigate mechanistic causes of physical injury, including potential construction of spillway deflectors. The Corps will defer an intake screen and bypass system implementation decision until other measures are fully evaluated and consider the installation of fish friendly turbine designs (e.g., minimum-gap turbine runners) as part of the turbine rehabilitation program.

John Day Dam. Spill levels, configurations, and facilities at John Day Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- A 12-hour spill from 6:00 p.m. to 6:00 a.m. (7:00 p.m. to 6:00 a.m., May 15th to July 31st), at 60% of the outflow up to the TDG gas cap
- Standard-length screens at all 16 main units
- A new juvenile fish monitoring facility that releases fish approximately 1,000 feet downstream of the powerhouse
- A 20-bay spillway, with new deflectors on 18 bays

The Corps will continue 24-hour spill investigations to determine juvenile passage and survival benefits; construct end deflectors by 2002 and assess water quality and fish survival benefits of deflector optimization; conduct surface bypass removable spillway weir prototype evaluation in 2002 as a surrogate for skeleton bay surface collection; continue to develop extended intake screen system; conduct prototype tests in 2001/2002; synthesize incremental juvenile survival benefits of all juvenile passage options in late 2002 and proceed with the most promising survival-improvement measures; and investigate less intrusive PIT-tag interrogation method for juvenile sampling facilities and implement them as warranted.

McNary Dam. Configurations and facilities at McNary Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- A 12-hour spill from 6:00 p.m. to 6:00 a.m. at the TDG cap
- Extended-length screens in all 14 main units
- Juvenile fish monitoring facility/collection and bypass, with the capability to either collect and transport fish via barge or truck, or release fish to the river
- A 22-bay spillway, with deflectors on 18 bays

The Corps will conduct spillway efficiency and effectiveness evaluations, spillway deflector optimization investigations, and surface bypass removable spillway weir prototype studies as appropriate (based on results at other locations); determine optimum spring migration juvenile

survival configuration and operations; implement promising measures; upgrade extended intake screens and implement gatewell screen cleaning and other juvenile bypass system improvements; investigate and implement remedies to address adult egress from juvenile bypass system; investigate a less intrusive PIT-tag interrogation method for juvenile sampling facilities; implement it as warranted; and evaluate the need for juvenile bypass outfall relocation.

Ice Harbor Dam. Configurations and facilities at Ice Harbor Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- A 24-four hour spill (with nighttime spill limited to the TDG at the cap and daytime spill limited to 45 kcfs for adult passage)
- Standard-length screens at all six main units
- A 10-bay spillway, with deflectors on 10 bays

The Corps will investigate and implement remedies to address adult egress from the juvenile bypass system; assess the provision of a less intrusive PIT-tag interrogation method for the Ice Harbor juvenile bypass system; consider, based on other studies, a surface bypass removable spillway weir (RSW); and consider the installation of fish-friendly turbines as part of the turbine rehabilitation program.

Lower Monumental Dam. Configurations and facilities at Lower Monumental Dam related to juvenile fish passage include the following operating criteria identified in this biological opinion or the Fish Passage Plan:

- A 24-hour spill at the gas cap
- Standard-length screens at all six main units
- Juvenile fish monitoring facility/collection and bypass, with the capability to either collect and transport fish via barge or truck, or release them to the river
- An eight-bay spillway, with deflectors on six middle bays

The Corps will continue the 24-hour spill; investigate a surface bypass RSW, spillway deflector optimization (including the addition of end bay deflectors), and juvenile bypass system separator replacement, as well as making other system improvements; investigate a new juvenile bypass outfall location; investigate an extended intake screen system; and implement the most promising measures to increase juvenile survival.

Little Goose Dam. Configurations and facilities at Little Goose Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- A 12-hour spill (6:00 p.m. to 6:00 a.m.) up to the gas cap
- Extended-length screens at all six main units
- Juvenile fish monitoring facility/collection and bypass, with capability to either collect and transport fish via barge or truck or release them to the river
- An eight-bay spillway, with deflectors on six middle bays

The Corps will investigate a surface bypass RSW, spillway deflector optimization (including addition of end bay deflectors), and replacing the juvenile bypass system separator, as well as making other system improvements; upgrade extended intake screens; investigate the effectiveness of 24-hour spill, either separately or in conjunction with a surface bypass RSW; implement those measures with the greatest promise of increasing juvenile survival; determine the need and frequency of powerhouse debris containment boom use to reduce predation losses; and implement debris removal criteria.

Lower Granite Dam. Configurations and facilities at Lower Granite Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- A 12-hour spill from 6:00 p.m. to 6:00 a.m. up to the gas cap
- Extended-length screens at all six main units
- Juvenile fish monitoring facility/collection and bypass, with the capability to either collect and transport fish via truck or barge, or release them to the river
- Prototype powerhouse surface collector
- An eight bay-spillway, with deflectors on eight bays

The Corps will initiate surface bypass RSW studies in 2001; complete design of juvenile bypass system improvements to add open-channel flume, juvenile separation by size, and other system improvements; upgrade extended intake screens; investigate the effectiveness of 24-hour spill, either separately or in conjunction with a surface bypass RSW; investigate spillway deflector optimization and implement it as warranted; defer a decision on permanent powerhouse surface bypass collector until other measures are fully evaluated; implement measures with the greatest promise of increasing juvenile survival; and add additional transport barges as warranted.

9.6.1.4.3 Current and Near-term Actions

Spill Program

Action 54: The Corps and BPA shall implement an annual spill program, consistent with the spill volumes and TDG limits identified in Table 9.6-3, at all mainstem Snake and Columbia River FCRPS projects as part of the annual planning effort to achieve the juvenile salmon and steelhead performance standards.

The annual spill program will be based on the best available monitoring and evaluation data concerning project passage, spill, and system survival research. The Action Agencies, in consultation with the Technical Management Team and with the approval of NMFS, will conduct a preseason determination of the specific annual spill levels and dates at each project. The planning dates for the annual spill program are April 3 to June 20 and June 21 to August 31 for the spring and summer migration periods, respectively, in the Snake River, and April 10 to June 30 and July 1 to August 31 for the spring and summer migration periods, respectively, in the lower Columbia River. Initial estimates of project spill levels, and the basis for each estimate, are shown in Table 9.6-3.

The specific spill volumes listed in Table 9.6-3 must be viewed as approximate because the TDG levels measured at the monitoring site below each project, at a given spill level, can vary with such factors as river flow, forebay dissolved gas level, spill patterns, and water temperature changes. Spill levels at some projects may change as spill patterns are refined or if deflector optimization measures are implemented. There are also project-specific limitations on spill levels for reasons other than TDG, including adult passage, navigation, and research activities. These limitations are typically of short duration, but they can affect spill for fish passage to a limited degree.

Interruptions or adjustments in spill may occur due to unforeseeable power system, flood control, or other emergencies. The Action Agencies should view such emergency actions as last resorts, and they should not be used in place of the long-term investments necessary to allow full, uninterrupted implementation of the required spill levels while maintaining other project purposes, such as an adequate and reliable power system.

Discussion of emergencies with effects of exceptional magnitude or duration should include involvement of regional executives. Section 9.4.2.2 provides for the development of more specific process modifications to address these needs in the water management plans.

9.6.1.4.4 Project-by-project Spill Requirements

Lower Granite Dam. To achieve the desired fish passage efficiencies, the 1995 FCRPS Biological Opinion set the Lower Granite spill level at 80% of total instantaneous discharge for

12 hours per day. Under most conditions, however, this level of spill could not be implemented because the gas cap was reached at spillway flows of 40 kcfs (1998 Supplemental FCRPS Biological Opinion). More recent information suggests that the gas cap will be reached at about 60 kcfs; this level is the appropriate current spill limit. Based on radio-tracking studies with adult chinook, performed at Lower Granite Dam during 1996 and 1997, a spill level of 60 kcfs does not appear to affect adult passage adversely (Bjornn 1998, Bjornn 2000). It may be necessary to reduce spill to accommodate safety concerns when juveniles are being loaded directly onto barges for transportation downstream, and the barges must be docked for extended periods. Spill operations must also consider research needs critical to the ongoing evaluation of the surface bypass prototype (e.g., project operations in 2000 have been modified to spill for 24 hours per day instead of only at night, and powerhouse operations have been modified to provide the required hydraulic conditions in the immediate forebay).

Table 9.6-3. Estimated spill levels and gas caps for FCRPS projects during spring (all) and summer (nontransport projects).

Project ¹	Estimated Spill Level ²	Hours	Limiting Factor
Lower Granite	60 kcfs	6 p.m. - 6 a.m.	gas cap
Little Goose	45 kcfs	6 p.m. - 6 a.m.	gas cap
Lower Monumental	40 kcfs	24 hours	gas cap
Ice Harbor	100 kcfs (night) 45 kcfs (day)	24 hours	nighttime - gas cap daytime - adult passage
McNary	120-150 kcfs	6 p.m. - 6 a.m.	gas cap
John Day	85-160 kcfs/60% ³ (night)	6 p.m. - 6 a.m. ⁴	gas cap/percentage
The Dalles	40% of instant flow	24 hours	tailrace flow pattern and survival concerns (ongoing studies)
Bonneville	90-150 kcfs (night) 75 kcfs (day)	24 hours	nighttime - gas cap daytime - adult fallback

¹ Summer spill is curtailed beginning on or about June 20 at the four transport projects (Lower Granite, Little Goose, Lower Monumental, and McNary dams) due to concerns about low inriver survival rates.

² Estimated spill levels shown in the table will increase for some projects as spillway deflector optimization measures are implemented.

³ The TDG cap at John Day Dam is estimated at 85 to 160 kcfs, and the spill cap for tailrace hydraulics is 60%. At project flows up to 300 kcfs, spill discharges will be 60% of instantaneous project flow. Above 300 kcfs project flow, spill discharges will be at the gas cap (up to the hydraulic limit of the powerhouse).

⁴ Spill at John Day Dam will be 7:00 p.m. to 6:00 a.m. (night) and 6:00 a.m. to 7:00 p.m. (day) between May 15 and July 31.

BPA has specified 11.5 kcfs as a minimum powerhouse flow for system reliability. Because this minimum depends on the status of generation at other projects, it may not be necessary at all times.

Little Goose Dam. The 1995 FCRPS Biological Opinion set the Little Goose Dam spill level at 80% of total instantaneous discharge 12 hours per day (NMFS 1998). As at Lower Granite Dam, the Action Agencies could not usually implement this level because the gas cap was reached at spillway flows of approximately 35 kcfs. More recent information suggests that the gas cap will be reached at about 45 kcfs; this level is the appropriate current limit at Little Goose Dam. Based on radio-tracking studies with adult chinook performed during 1997, a spill level of 60 kcfs did not appear to affect adult passage adversely (Peery 1998).

BPA has specified 11.5 kcfs as a minimum powerhouse flow for system reliability. Because this minimum depends on the status of generation at other projects, it may not be necessary at all times.

Lower Monumental Dam. The 1995 FCRPS Biological Opinion set the Lower Monumental Dam spill level at 81% of total instantaneous discharge for 12 hours per day (NMFS 1998). Again, this level of spill was not provided voluntarily, because the gas cap was reached at spillway flows of approximately 40 kcfs. The estimate of spill at the gas cap has not changed. Spill levels to the gas cap will now, however, be provided for 24 hours per day. Based on radio-tracking studies with adult chinook performed during 1997, a spill level of 45 kcfs did not appear to affect adult passage adversely (Peery 1998, Bjornn 2000). Because the gas cap is currently reached at approximately 40 kcfs, no reduction in spill is necessary for adult passage.

Accelerated erosion in the spillway stilling basin apron has recently been noted as a concern by the Corps. NMFS is concerned that the Corps may decide, for safety reasons, to limit fish passage spill until the noted erosion is corrected. To ensure that 24-hour fish passage spill, as described above, is not limited, the Corps and BPA will respond to the problem by initiating timely corrective measures.

BPA has specified 11.5 kcfs as a minimum powerhouse flow for system reliability. Because this minimum depends on the status of generation at other projects, it may not be necessary at all times.

Ice Harbor Dam. The 1995 FCRPS Biological Opinion prescribed spill levels at Ice Harbor Dam of 27% in the spring and 70% in the summer, each for 24 hours per day. The 27% spring objective was often reached, even though the gas cap limited voluntary spill to flows of 25 kcfs. The summer target of 70% was also reached at the lower flow levels (NMFS 1998). Due to the installation of spillway flow deflectors, more recent information suggests that the gas cap will be reached at 100 kcfs. Based on research performed during the early 1980s, adult passage would become a concern at daytime (5:00 a.m. to 8:00 p.m.) spill in excess of 45 kcfs. Recent information from radio-tracking studies performed from 1996 to 1998 suggests that spill levels

from 55 to 70 kcfs did not appear to affect adult passage adversely (Peery 1998, Bjornn 2000). The 45-kcfs, adult-passage daytime cap may have to be reconsidered once the final study results are available. No change is now proposed, however, and the daytime limit remains 45 kcfs.

BPA has specified 7.5 to 9.5 kcfs as minimum powerhouse flows for system reliability. Because this minimum depends on the status of generation at other projects, it may not be necessary at all times.

McNary Dam. The 1995 FCRPS Biological Opinion set the McNary Dam spill level at 50% of total instantaneous discharge for 12 hours per day (NMFS 1998). Due to limited powerhouse capacity, and because the gas cap was reached at spillway flows of 120 kcfs, these spill levels were reached under most conditions. More recent information suggests that the gas cap will be reached at about 135 kcfs.

BPA has specified a minimum powerhouse flow of 50 kcfs to maintain power transmission system stability.

John Day Dam. The 1998 FCRPS Supplemental Biological Opinion set the John Day Dam spill level at 60% of total instantaneous discharge up to the gas cap during the nighttime hours. At project flows up to 300 kcfs, spill discharges will be 60% of instantaneous project flow during 12 hours per day. Above 300 kcfs, spill discharges will be the gas cap (up to the hydraulic limit of the powerhouse). With the completion of spillway deflectors and new spill patterns, gas cap spill flow has ranged up to 170 kcfs. Spill limits of 25% minimum and 60% maximum are imposed to ensure adequate juvenile egress conditions from the spillway at low spill flows and from the juvenile bypass system during high spill flows. General physical model studies have indicated that spill percentages below 25% create poor egress conditions (eddies and slack water) in the spillway tailrace, and spill levels above 60% tend to create a large eddy in the tailrace below the powerhouse that can actually cause flow from the bypass to move upstream.

BPA has specified a minimum powerhouse flow of 50 kcfs to maintain power transmission system stability.

The Dalles Dam. The 1995 FCRPS Biological Opinion prescribed a spill level at The Dalles Dam of 64% for 24 hours (NMFS 1998). Spill survival studies NMFS conducted in 1997, 1998, and 1999 indicated that the 64% spill level can result in relatively low spillway survival compared to fish released below the project. These studies also indicated that a 30% spill level spillway survival was always as good or higher than the 64% level. Companion studies using radio-tagged fish and hydroacoustic monitoring indicated that reducing the spill percentage from 64% to 30% caused more fish to pass through the powerhouse sluiceway and turbines. Turbine survival has not been measured at this project, but it is assumed to be no better than that observed at other projects. Details of these studies and references can be found in NMFS 2000a.

Based on the available information, the ISAB recommended an evaluation of 24-hour spill levels at The Dalles in the 30% to 50% range (ISAB 2000). NMFS recommends an evaluation of 24-hour spill at the 40% level and expects to improve juvenile fish survival with this interim spill operation (see Section 9.6.1.4.5). Additionally, because reduced juvenile survival at higher spill levels may have been related to the daylight adult spill pattern, there is potential for higher than 40% nighttime spill with a juvenile passage pattern after The Dalles survival tests are concluded, and the results are evaluated. Upon completion of these tests, modified spill levels and patterns should be evaluated for adult passage and fallback.

BPA has specified a minimum powerhouse flow of 50 kcfs to maintain power transmission system stability.

Bonneville Dam. The 1998 FCRPS Supplement established a nighttime spill level at the TDG cap generally between 90 and 150 kcfs for the duration listed in the current Corps' Fish Passage Plan. The minimum spill level will be no less than 50 kcfs of the total river flow to provide good tailrace egress of juvenile migrants. Daytime spill levels are limited to 75 kcfs at Bonneville Dam due to concerns for adult salmonid fallback through the spillway. Recent evidence from adult radio-tracking studies conducted in 1996, 1997, and 1998 indicates that increases in adult fallback associated with increased daytime spill flows from 75 to 120 kcfs range are relatively small. Juvenile passage benefits from the increased spill level would likely outweigh small adult losses that may be associated with the higher spill level. Further, spillway deflector optimization improvements may result in more uniform spill gate openings, which could reduce adult fallback rates. NMFS believes this issue warrants further investigation. Planned studies are described below.

BPA has specified a minimum powerhouse flow of 30 kcfs.

System Actions to Improve Spill Capability

Action 55: To improve the future flexibility of the transmission system, BPA's Transmission Business Line shall initiate planning and design necessary to construct a Schultz-Hanford 500-kV line or an equivalent project, with a planned schedule for implementation by 2004 or 2005.

This line would make additional daytime spill possible in the lower Columbia to help meet performance standards by restoring approximately 200 to 300 MW of California transfer capability. Because construction of this new line will require congressional and NEPA review, BPA's Transmission Business Line should begin this planning effort in 2000.

Action 56: BPA's Transmission Business Line shall continue efforts to evaluate, plan, design, and construct a joint transmission project to upgrade the west-of-Hatwai cutplane⁷ and improve the transfer limitations from Montana.

Although the specific type of project to be implemented has not been identified at this time, this project is expected to be completed in the 2003-to-2004 time frame. This upgrade would make additional daytime spill possible at the Snake River dams to help meet performance standards by restoring approximately 500 MW of Montana transfer capability. Since this project will also require NEPA review, BPA's Transmission Business Line should begin this joint planning effort in 2000.

Action 57: BPA's Transmission Business Line shall continue to evaluate strategically located generation additions and other transmission system improvements and report progress to NMFS annually. BPA's Transmission Business Line shall also limit future reservations for transmission capacity, as needed, to enable additional spill to meet performance standards, while minimizing effects on transmission rights holders.

If additional spill is found to be appropriate at FCRPS projects (more than the capacity that the Schultz-Hanford project provides), further transmission system reinforcements may be required to enable obtaining it and restoring any additional lost capacity. BPA's Transmission Business Line has made only a cursory examination of these potential transmission system reinforcements. The most promising candidates are major 500-kV lines in the Interstate Highway 5 (I-5) corridor; however, such new lines would be very costly and challenging to site. If work on these projects started in 2002 (pending favorable results in ongoing spill studies), completion of these reinforcements would be expected in the 2007-to-2010 timeframe. In addition, several new gas-fired combustion turbines south of the John Day cutplane (with a total capacity of about 1,250 MW of base load generation) are being licensed and could be operational by the summer of 2002. If additional spill is found to be appropriate, and before long-term fixes can be implemented, BPA will limit future reservations for transmission capacity, as appropriate, to enable spill while minimizing effects on existing transmission rights holders.

Turbine Unit Operations

Action 58: The Corps and BPA, in coordination with the Fish Passage Operations and Maintenance Coordination Team (FPOM), shall operate all turbine units at FCRPS dams for optimum fish passage survival. Methods to achieve this

⁷Cutplanes are reference points on a set of transmission lines that define capacity restrictions under certain operating conditions or when facilities are out of service. These reference points, when linked together, form a line (or a plane) that defines an operating constraint in the transmission system. That is, there is a limit to the amount of electricity that can flow across this plane. Thus, they are identified with transmission constraints.

objective shall include, but are not limited to, activities outlined in the following paragraphs.

The Corps and BPA will operate turbines within 1% of peak efficiency during the juvenile and adult migration seasons (March 15 through October 31 in the Columbia River and March 15 through November 30 in the Snake River) as indicated by the load-shaping guidelines contained in the Corps' annual Fish Passage Plan. These guidelines will be updated through the Fish Passage Plan review process before February 1 each year. Operating turbines at peak efficiency is believed to provide the highest survival of anadromous species during passage through a turbine (Bell et al. 1981, Eicher 1987).

The Corps and BPA will continue efforts to index-test all families of turbine units specific to each project in the FCRPS to ensure that peak efficiency tables listed in the Fish Passage Plan reflect current operating conditions. This work will be completed by 2003. This will include index testing and development and implementation of operational cam curves. These curves will be developed and updated as necessary to reflect current fish passage conditions (screens, surface collectors, unit modifications, etc.). This work will be coordinated through FPOM.

Action 59: The Action Agencies, in coordination with the Regional Forum, shall determine the appropriate operating range of turbines equipped with minimum gap runners (MGRs) to increase survival of juvenile migrants passing through these new turbine designs.

The Action Agencies will evaluate the potential for exceeding the upper limit of the 1% efficiency band to improve fish survival related to passage through turbines with MGR technology. The evaluation will include an examination of indirect consequences (in terms of fish survival) of exceeding the 1% peak efficiency guidelines (including screen effects, gatewell hydraulics, draft tube and tailrace conditions, etc.). The Action Agencies will report results of this evaluation to NMFS by October 2003. Other turbine designs may be evaluated if study designs and priorities are approved as part of the annual planning process.

9.6.1.4.5 Studies (Including Research, Monitoring, and Evaluations)

Bonneville Dam

Action 60: The Corps and BPA shall evaluate adult fallback and juvenile fish passage under daytime spill to the gas cap at Bonneville Dam in 2002 and 2003, after deflector optimization improvements allow for increased spill above current levels. Research results will be considered, in consultation with NMFS through the annual planning process, to determine implementation of additional changes in spill to further improve fish survival.

Research goals will include rate of adult fallback and juvenile passage change between 75 kcfs and new gas cap spill levels attainable through deflector optimization. The future daytime spill level will depend on the results of this study. The study design for future spill evaluations, and the resulting changes in the annual spill operation, should be coordinated through NMFS' Regional Forum process.

Further modifications to spill operations suggested by the studies at this project for 2002 and beyond may be limited pending transmission system improvements expected to come on-line by 2005 or earlier by potential modifications to spill operations at The Dalles and John Day dams. Other actions may improve the flexibility and reliability of the transmission system by an earlier date.

Action 61: The Corps shall complete the ongoing prototype powerhouse system surface collection evaluations at Bonneville First Powerhouse in 2000. The Corps shall compare the prototype with screened bypass systems and, if warranted, design and construct permanent facilities after full consideration and resolution of biological and engineering uncertainties, especially high-flow outfall investigations.

Existing Bonneville First Powerhouse juvenile passage facilities guide a relatively low percentage of fish away from turbines, and guided fish are bypassed to an outfall site with predator aggregations. The full potential of a surface collection and high-flow bypass outfall system has to be identified, then weighed against other alternatives.

Action 62: The Corps shall complete Bonneville First Powerhouse prototype evaluations of extended submerged intake and gateway vertical barrier screens, including an assessment of fry passage.

The Corps will continue design development of improved screens, a downstream migrant collection channel, and connection to the new juvenile bypass monitoring facilities and outfalls.

Action 63: The Corps shall complete the design of debris removal facilities for the Bonneville First Powerhouse forebay.

If the decision is made to install a new extended-length screen and bypass system at this powerhouse in 2001, the Corps will install debris-removal facilities as warranted. Special consideration should be given to potential predation and juvenile fish entrainment problems associated with debris booms.

Action 64: The Corps shall continue the investigation of minimum gap runners at the Bonneville First Powerhouse.

The Corps will continue investigation of the new minimum gap runners at Bonneville Dam First Powerhouse to ensure that the new runner environment provides improved survival for juvenile

migrants that pass through turbines. The Corps will submit a report to NMFS stating the findings of these investigations by February 2001.

Action 65: The Corps shall complete Bonneville Second Powerhouse post-construction evaluation of the new juvenile fish bypass outfall and address design and operational refinements as warranted.

Issues such as smolt survival, fry impingement and loss, and potential design deficiencies will have to be investigated and corrected, as necessary.

Action 66: The Corps shall continue design development and construction of a Bonneville Second Powerhouse permanent corner collector at the existing sluice chute, pending results of high-flow outfall investigations. The Corps shall construct new facilities if, and as soon as, evaluations confirm the optimum design configuration and survival benefits.

Prototype testing in 1998 showed that numerous juveniles entering the forebay were collected by the sluice chute. The decision to proceed with this measure is contingent on identifying whether an optimum bypass outfall location can be selected that will minimize mechanical and predation losses in the tailrace.

Action 67: The Corps shall continue Bonneville Second Powerhouse investigations of measures to improve intake screen fish guidance efficiency and safe passage through the gateway environment. This work shall include an assessment of fry passage.

The Bonneville Second Powerhouse bypass system has a state-of-the-art fish conveyance system coupled with relatively low fish guidance efficiency. Improving guidance of this system is an obvious next step to improving powerhouse passage, pending decisions on the optimal mix of actions at the second powerhouse for contributing to the performance standard.

The Dalles Dam

Action 68: The Corps and BPA shall continue spill and passage survival studies at The Dalles Dam in 2001. Research results shall be considered, in consultation with NMFS through the annual planning process, to assess the need for additional changes in spill to further improve fish survival by 2002, if possible, but no later than 2005.

The goal of these studies is to evaluate spillway survival by using a spill level that balances the risks associated with high spill levels and increased turbine passage. These studies should also include evaluation of survival rates through the other routes of passage at this project. These studies should investigate the causes of spillway mortality. Subsequent studies should assess the need for remedial actions.

Future changes in spill levels at The Dalles will depend on the results of the ongoing survival and spill passage studies. The study design for any future studies, and the resulting changes in the annual spill operation, will be coordinated through the annual planning process.

Further modifications to spill operations suggested by the studies at this project for 2002 and beyond may be limited pending transmission system improvements expected to come on line by 2005 or, before then, on potential modifications to spill operations at Bonneville and John Day dams. Other actions may improve the flexibility and reliability of the transmission system by an earlier date.

Action 69: The Corps shall continue design development and 2001 prototype testing of upper turbine intake occlusion devices at The Dalles, with a goal of increased non-turbine passage rates through either the sluiceway or the spillway. The Corps shall install occlusion devices across the entire powerhouse, as warranted.

Occlusion of upper intakes is a promising method of reducing turbine entrainment and associated mortality.

Action 70: The Corps shall continue biological and engineering investigations and design of a composite ice and trash sluiceway outfall relocation and adult ladder auxiliary water system at The Dalles Dam and shall construct such devices as warranted.

The existing ice and trash sluiceway is a highly efficient surface collector. However, recent PIT-tag survival data suggest that survival is unacceptably low. Relocation of the outfall to improve passage survival will also provide the opportunity to develop a combined system whereby excess water can be used to augment the auxiliary water supply for the east adult fishway.

John Day Dam

Action 71: The Corps and BPA shall continue investigation of 24-hour spill at John Day Dam in 2001. Research results will be considered, in consultation with NMFS through the annual planning process, to determine implementation of daytime spill to further improve juvenile fish survival as needed for its contribution to the performance standard.

High spillway effectiveness and high daytime passage were noted during 24-hour spill in 1997 and 1999. The 1999 studies indicated a significant reduction in forebay residence time for chinook and smaller (primarily wild) steelhead. These observations and the study limitations imposed by ambient flow conditions in 1999 warrant further investigation during the spring and summer seasons in 2001.

The framework for the ongoing study is as follows:

- The study goals identify juvenile salmonid response to daytime spill in terms of spillway passage, forebay residence time, and overall passage survival.
- The scope of the study will include both spring and summer spill.
- Adult passage considerations and potential adult fallback will be considered in the study design.
- The study plan will be reviewed through the annual planning process.

Further modifications to spill operations suggested by project studies for 2002 and beyond will be coordinated through the annual planning process and may be limited pending transmission system improvements expected to come on line by 2005. Other actions may improve the flexibility and reliability of the transmission system by an earlier date.

Action 72: The Corps shall continue design development of a prototype RSW and extended deflector for testing at John Day in 2002. The Corps should synthesize evaluation results, determine the fish survival benefits of one or more RSWs or a skeleton bay surface bypass, and install the units as warranted.

Surface-oriented entrances, such as those provided by a prototype RSW, have the potential to pass a high percentage of juveniles, potentially more than if the same flow is passed through the deeper conventional spill gates.

Action 73: The Corps shall continue John Day prototype development and investigations of extended submerged intake screens, gatewell vertical barrier screens, and, if necessary, orifices to optimize guidance and safe passage through the system, including a gatewell debris cleaning plan. This work shall include an assessment of fry passage. The Corps shall design and construct new screen systems for safe passage of juvenile salmonids, as warranted. Juvenile bypass outfall survival investigations shall also be conducted.

Prototype investigations have indicated that extended screens have the potential to guide up to 28% more juvenile salmon away from the turbine intakes at this project when compared to standard-length screens. Unfortunately, gatewell hydraulics were found to injure an unacceptable number of the guided fish. Model and prototype investigations are necessary to resolve the injury problem and provide safe passage conditions observed at other projects with extended-length screens. To ensure improved guidance results and improved passage survival, bypass outfall survival investigations should also be conducted.

McNary Dam

Action 74: The Corps shall continue evaluations to assess the need for improvements of the existing intake screens, gatewell vertical barrier screen cleaning system, and bypass facilities (including debris containment and removal systems, separation, sampling, loading, and outfall facilities) at McNary to determine where improvements are necessary to reduce problems experienced during the 1996 flood, increase fish survival, and resolve holding and loading facility problems, including raceway jumping by juvenile salmon and steelhead and debris plugging of bypass lines. Additionally, the Corps shall evaluate whether the existing juvenile bypass system outfall should be relocated.

The McNary Dam juvenile fish intake screening and bypass system experienced the most adverse effects associated with 1996 flooding and is the passage facility most in need of upgrades. The Corps will implement improvements as warranted.

Action 75: The Corps shall investigate a surface bypass RSW at McNary Dam, based on prototype results at other locations, and shall install the unit in multiple spillway bays, as warranted.

The potential for improved spillway passage through use of RSWs has to be investigated in the context of current spillway passage percentages for spring migrants at McNary Dam, where there is currently no spring transportation program and no voluntary fish spill during the 12 daytime hours.

Lower Monumental Dam

Action 76: The Corps shall investigate, design, and construct, as warranted, a new juvenile bypass outfall at Lower Monumental Dam. Investigations shall be conducted in conjunction with spillway deflector and spill pattern optimization studies.

The existing outfall site is poor because the tailrace current frequently flows upstream toward the powerhouse, and the outfall facilities recently were damaged by a transport barge. The new outfall shall be designed to return both PIT-tagged fish and primary bypass flow to the river.

Action 77: The Corps shall investigate surface bypass (e.g., RSW) at Lower Monumental Dam, based on prototype results at other locations, and install in multiple spillway bays, as warranted.

Use of one or more RSWs at Lower Snake hydro projects will potentially increase safe spillway passage during periods of low to moderate spill.

Action 78: The Corps shall initiate design development and testing of extended submerged intake screens and vertical barrier screens at Lower Monumental Dam and construct units as warranted.

Lower Monumental Dam presently has standard screens. Improved fish guidance efficiency would enhance survival of fish entrained at powerhouse turbine intakes by diverting a higher proportion away from turbine passage where they are subject to direct mechanical and/or indirect mortality.

Little Goose Dam

Action 79: The Corps shall conduct a post-construction evaluation of the new debris containment boom at Little Goose to monitor populations and behavior of aquatic predators when debris accumulates at the log boom.

The Corps should develop criteria for initiation of debris removal at the new log boom before the 2002 passage season and assess log boom predator aggregation in both wet and dry years. The Corps will alter criteria and address predation, as warranted.

Lower Granite Dam

Action 80: The Corps shall continue the design development, fabrication/deployment, and testing of a prototype RSW at Lower Granite, in conjunction with the existing prototype powerhouse occlusion devices, including the forebay behavioral guidance structure (BGS) and upper turbine intake occlusion devices. As warranted by prototype test results, the Corps shall install one or more permanent RSWs and occlusion devices at appropriate lower Snake hydro projects, in coordination with the annual planning process.

Use of one or more RSWs, in possible combination with occlusion systems at lower Snake hydro projects, will potentially increase safe spillway passage and survival, reduce forebay residence time, reduce stress, and potentially reduce gas supersaturation due to higher spillway passage efficiencies.

Action 81: The Corps shall complete design for new juvenile bypass facilities at Lower Granite Dam, including enlarged orifices and bypass gallery, open-channel flow bypass, improved separator for juvenile separation by size, and improved fish distribution flumes and barge-loading facilities and shall proceed to construction, as warranted.

Lower Granite is the first mainstem dam on the Snake River encountered by migrating juvenile salmon and steelhead. This location offers the greatest potential for collecting the largest number of smolts for transportation. Unlike the other dams, there is presently no way to separate juvenile

fish by size. Such size separation is believed to reduce stress and enhance long-term survival. Juvenile collection/bypass facilities at all of the other collector projects have been upgraded with state-of-the-art improvements over the last decade. These improvements are necessary, while additional information on the benefits of transportation is collected.

9.6.1.4.6 System or General Studies (including Research, Monitoring, and Evaluations)

Action 82: The Action Agencies, in coordination with NMFS through the annual planning process, shall investigate the spillway passage survival of juvenile salmonids at appropriate FCRPS dams. These investigations shall assess the effect of spill patterns and per-bay spill volumes on fish survival, across a range of flow conditions. The Action Agencies shall develop a phased approach (including costs and schedules) and set priorities, in consultation with NMFS in the annual planning process, to continue spillway passage survival studies in 2001 and future years.

Spillway passage has become an increasingly important route for juvenile salmonids at FCRPS dams. These studies will ensure that each spillway is operated in a manner that results in the lowest possible direct and indirect mortality.

Action 83: The Action Agencies, in coordination with NMFS through the annual planning process, shall evaluate the effect of spill duration and volume on spillway effectiveness (percent of total project passage via spill), spill efficiency (fish per unit flow), forebay residence time, and total project and system survival of juvenile steelhead and salmon passing FCRPS dams. Studies shall include both collector and non-collector projects. Adult passage considerations and potential adult fallback shall also be considered in study designs. Little Goose and Lower Granite dams shall be specifically considered for daytime spill studies. An overall phased study approach for spill evaluations will be determined in the 1- and 5-year implementation plans.

Whereas the current nighttime spill regime is based on NMFS' understanding of hours of peak daily juvenile fish passage, it is clear that fish move throughout the day and that, as a result, longer spill hours may improve juvenile fish survival past the dams by increasing the proportion of fish passing in spill. Spill changes to improve fish survival may include reshaping current volumes or spilling increased volumes. There may also be operational changes associated with spill patterns or hourly project operations that influence the proportion of fish passed through spill.

It may also be possible to reduce delay when fish first encounter the dam and, thereby, limit exposure to predation in project forebays. Conversely, longer spill hours could have negligible-to-measurable adverse biological effects, such as delay, fallback of adults, or increased exposure to dissolved gas supersaturation. The intent of the efficiency and effectiveness information is to

ensure optimal use of current and future spill volumes to achieve the biological performance standards. Any resulting changes in the annual spill operation will be coordinated through the annual planning process.

The research actions called for above are proposed to further evaluate the fish spill program at selected projects. In addition, NMFS believes that obtaining and reviewing the results of these evaluations will assist in making appropriate future modifications in the spill program to improve both fish survival and water quality.

To the extent that greater spill duration and/or volumes are required for the purposes of spill evaluation at some projects, efforts will be made to minimize or offset additional effects to the power system.

Action 84: The Corps shall continue high-flow outfall investigations to determine whether it is appropriate to modify bypass outfall criteria in the context of high-discharge bypass discharges.

Development of high-flow outfalls for surface collector/bypass systems requires verification of negligible mechanical and predation losses as flow plunges into the tailrace at high velocities. This research is relevant at numerous sites.

Action 85: The Corps shall continue to develop and evaluate improved fish-tracking technologies and computational fluid dynamics (numerical modeling). The ability to integrate these technologies and fluid dynamics shall be assessed as a potentially improved means of determining fish responses to forebay hydraulic conditions.

More precise understanding of fish behavioral responses to forebay hydraulic and other conditions is required to optimize future fish collection and bypass system designs. Integrated use of improved fish tracking and numerical modeling offers the potential for research advances that will lead to survival enhancement measures.

Action 86: The Corps shall continue to investigate a way to increase entry rates of fish approaching surface bypass/collector entrances.

Deep, wide surface collector entrances, similar to the successful Wells Dam surface collector system, have been studied at Corps prototype sites, but performance has been marginal. Therefore, a study is needed to evaluate fish behavior and flow-fields of large surface-oriented entrances that are believed to be highly efficient and effective, such as The Dalles ice and trash sluiceway.

Action 87: The Corps and BPA shall assess less-intrusive, PIT-tag interrogation methods at FCRPS juvenile bypass systems with interrogation sites, including McNary, John

Day, and Bonneville dams. The Corps and BPA shall also assess providing a similar detection capability for the Ice Harbor juvenile bypass system.

The Corps and BPA should assess the use of full bypass flow PIT-tag detection, without the need to dewater and route fish through separators and sample flumes. This type of system reduces the potential for adverse survival effects of passage through these bypass systems.

Action 88: The Corps and BPA, in coordination with the Fish Facility Design Review Work Group and the Fish Passage Improvement Through Turbines Technical Work Group, shall continue the program to improve turbine survival of juvenile and adult salmonids.

Action 89: The Action Agencies shall investigate hydraulic and behavioral aspects of turbine passage by juvenile steelhead and salmon through turbines to develop biologically based turbine design and operating criteria. The Corps shall submit a report to NMFS stating the findings of the first phase of the Turbine Passage Survival Program by October 2001. Annual progress reports will be provided after this date.

Action 90: The Action Agencies shall examine the effects of draft tubes and powerhouse tailraces on the survival of fish passing through turbines.

The evaluation should include biological and hydraulic evaluations and, if warranted, implementation of measures to reduce the effects of turbine backroll on juvenile salmonid survival, as well as the potential for reducing physical and hydraulic predator habitat in the tailrace environment. Action should also be taken to close draft tube gate closure slots at dams where these exist.

Action 91: The Action Agencies shall remove all unnecessary obstructions in the higher velocity areas of the intake-to-draft tube sections of the turbine units.

Unnecessary obstructions include miscellaneous hardware attachment points, handles, bolt heads, etc. Methods to streamline escape ladders, flow splitters, and other necessary obstructions should be evaluated and implemented, if feasible.

Action 92: The Action Agencies shall consider all state-of-the-art turbine design technology to decrease fish injury and mortality before the implementation of any future turbine rehabilitation program (including any major repair programs, the ongoing rehabilitation program at The Dalles Dam, and any future program at Ice Harbor Dam). The Action Agencies shall coordinate within the annual planning process before making decisions that would preclude the use of fish-friendly technologies and to minimize any adverse effects of project downtime.

Action 93: The Action Agencies shall determine the number of adults passed through turbines, then, if warranted, investigate the survival of adult salmonid passage through turbines (including steelhead kelts).

This program will include baseline passage evaluation and survival estimates and an investigation of hydraulic and behavioral aspects of turbine passage. This information will be used to develop biologically based turbine design and operating criteria.

Action 94: The Corps shall continue to evaluate the need for improvements of the existing intake screens, gatewell vertical barrier screens' cleaning system, and bypass facilities (including debris containment and removal systems, separation, sampling, loading, and outfall facilities) at the four lower Snake River hydropower projects.

The objective of these investigations is to upgrade intake screen, bypass, and loading facilities to modify and/or incorporate new components, especially in cases where problems have been identified since original design and construction. This includes investigation and implementation of measures to reduce raceway jumping.

Action 95: The Corps shall complete investigations of improved wet separator designs in 2002. The Corps shall design and construct a new wet separator at McNary, Lower Monumental, and Little Goose dams, as warranted.

The Corps will conduct post-construction evaluations of improved juvenile fish separation performance.

Action 96: The Corps shall complete the extended submerged intake screen systemwide letter report and implement recommended improvements.

The Corps will complete an investigation of fish performance and engineering issues pertaining to the need for improved porosity-control panel and panel connection design and install improved panels in all extended submerged intake screens. In particular, the Corps will develop improved vertical barrier screen gatewell cleaning and inspection measures for McNary and John Day dams and implement them as warranted. Also, the Corps will develop improved debris handling measures in the forebays and screen/bypass systems to limit juvenile injury and mortality. The Corps will implement other measures related to extended-length screen improvements, as warranted.

*9.6.1.4.7 Configuration Alternatives and Decision Dates*Bonneville Dam—First Powerhouse

Action 97: By January 2002, the Action Agencies shall develop an analysis that compares the relative passage survival benefits of an extended-length, intake screen bypass system, a surface-collection bypass system, and hybrid alternatives at Bonneville First Powerhouse. Through the annual planning process, the Corps shall determine which of these configurations to implement.

Two configuration alternatives are under evaluation for an improved bypass system at Bonneville First Powerhouse. One alternative completely upgrades the existing conventional bypass system by replacing the standard-length intake screens with extended-length screens, upgrading the collection gallery, and relocating the outfall. The other alternative employs the developing surface attraction and collection technology in front of the powerhouse and passes juveniles in a collection channel to a new outfall site downstream. Intake screens and surface collection may work best in tandem, suggesting that a hybrid of the two systems may be a third alternative configuration. The decision on which alternative to implement may be made as early as January 2001, but no later than January 2002.

John Day Dam

Action 98: By January 2003, the Action Agencies shall develop an analysis that compares the relative passage survival benefits of replacing existing standard-length intake screens with extended-length screens at the John Day Dam powerhouse to surface collection at one or more skeleton or spillway bays. Through the annual planning process, the Action Agencies shall then determine the need for, and the implementation priority of, these configuration alternatives.

Two different configuration alternatives are currently under evaluation at John Day Dam. Extended-length screens have been under development and evaluation for several years. Evaluation to date has indicated that the screens increase FGE. In 1999, research confirmed excessive mortality in the gatewells. Excessive gatewell turbulence is suspected as the cause of the mortality, and a new vertical barrier screen design is being developed. Surface collection technology has yet to be evaluated at John Day Dam. An RSW is under development for prototype evaluation in 2002. This requires that the Action Agencies make a determination by 2003, through the annual planning process, about the need for and implementation priority of these alternatives at John Day.

Lower Monumental Dam

Action 99: By January, 2003, the Action Agencies shall develop an analysis that compares the relative passage survival benefits of replacing existing standard-length intake

screens with extended-length screens at the Lower Monumental Dam powerhouse turbines to a removable RSW surface bypass system.

Twenty-four-hour spill was implemented at Lower Monumental Dam in spring 2000. Configuration alternatives include extended intake screens and one or more RSWs. Extended intake screen performances at other sites are known, and RSW fish passage efficiency will be studied at Lower Granite Dam in 2001. The Action Agencies will determine, through the annual planning process, which configuration alternatives to test or implement at Lower Monumental Dam.

9.6.1.5 Reservoir Passage

In general, juvenile mortality in reservoirs typically is associated with predation. While predation may be the primary cause of mortality, many factors contribute to vulnerability to predation, including water temperature, delay of passage or migration, TDG supersaturation, fish condition, disease, turbidity, lack of cover, etc. Various ongoing measures that directly reduce predation of juvenile outmigrants (e.g., Northern Pikeminnow Management Program) or may indirectly affect potential predation (water management, including releases of cool water, 24-hour spill, spill patterns, avian lines, water cannons, etc.) should continue. The Action Agencies should also develop other approaches that may contribute to reducing reservoir mortality.

9.6.1.5.1 Predator Control Strategy. The riverine ecosystems of the lower Snake and lower Columbia rivers have been altered dramatically by the development of the FCRPS. This development, and associated fish management practices, has created an environment that has benefitted a variety of species that prey on juvenile and adult salmonids. Studies cited in the Predation White Paper (NMFS 2000f) indicate that relatively large numbers of juvenile salmonid migrants are eaten by a variety of piscivorous fish, birds, and marine mammals. The northern pikeminnow alone is responsible for the loss of approximately 8% of the juvenile salmonid migrants in the system, and gulls were estimated to take 2% of all migrants passing one Columbia River dam. Marine mammal damage has been observed on up to 19% of the adult spring/summer chinook passing Lower Granite Dam. NMFS recognizes that death, injury, and health problems resulting from dam and reservoir passage and the presence of non-indigenous predator species are issues that will persist regardless of how predation is managed. It also recognizes that native predators are a part of the river ecosystem. Nevertheless, NMFS believes that some degree of predator control is necessary and that the following measures will help achieve the survival performance goals identified in this biological opinion, particularly related to the 10% reduction in reservoir mortality estimates.

9.6.1.5.2 Current and Near-term Actions

Action 100: The Action Agencies shall continue to implement and study methods to reduce the loss of juvenile salmonids to predacious fishes in the lower Columbia and lower Snake rivers. This effort will include continuation and improvement of the

ongoing Northern Pikeminnow Management Program and evaluation of methods to control predation by non-indigenous predacious fishes, including smallmouth bass, walleye, and channel catfish.

Northern pikeminnow, smallmouth bass, channel catfish, and walleye are important predators of juvenile salmon (Poe et al. 1991, Tabor et al. 1993). Various studies conducted in the 1980s indicated that northern pikeminnow predation in John Day Reservoir alone consumed between 1.4 and 3.3 million juvenile salmonids each year. Predator control efforts to date have focused on removing northern pikeminnow from the Snake and Columbia rivers and evaluating the behavior and distribution of predators in the near-dam and reservoir reaches. Additional emphasis should be placed on other predatory species in areas where those species cause significant loss of juvenile salmonids (see Section 9.6.1.5.3, below).

The effects of predator fish removal, habitat modifications, and management operations should be evaluated periodically as long as the programs continue. Such evaluation should include the effect on juvenile salmon survival, changes in target predator species population structures, and possible compensation by other predatory species.

Action 101: The Corps, in coordination with the NMFS Regional Forum process, shall implement and maintain effective means of discouraging avian predation (e.g., water spray, avian predator lines) at all forebay, tailrace, and bypass outfall locations where avian predator activity has been observed at FCRPS dams. These controls shall remain in effect from April through August, unless otherwise coordinated through the Regional Forum process. This effort shall also include removal of the old net frames attached to the two submerged outfall bypasses at Bonneville Dam. The Corps shall work with NMFS, FPOM, USDA Wildlife Services, and USFWS on recommendations for any additional measures and implementation schedules and report progress in the annual facility operating reports to NMFS. Following consultation with NMFS, corrective measures shall be implemented as soon as possible.

Bird predation marks are among the most common injuries observed on juvenile steelhead at smolt monitoring sites. During 1995 and 1996, 15% and 10%, respectively, of all the hatchery steelhead examined at John Day Dam exhibited bird predation marks (Martinson et al. 1997). These observations may indicate a high rate of juvenile steelhead predation that could be reduced with appropriate measures. The net frames at Bonneville Dam are no longer used for research and have become favored perching areas for fish-eating cormorants and gulls. The Corps will coordinate scoping and implementation of predator control measures with USFWS to ensure that the measures do not endanger bald eagles, osprey, and other bird species that are afforded Federal protection.

Any avian control measure involving capture or killing of migratory birds will require a permit issued by USFWS under the procedures and standards set out in the Migratory Bird Treaty Act and in USFWS's implementing regulations.

9.6.1.5.3 Studies (Including Research, Monitoring, and Evaluation)

Action 102: The Action Agencies, in coordination with the Caspian Tern Working Group, shall continue to conduct studies (including migrational behavior) to evaluate avian predation of juvenile salmonids in the FCRPS reservoirs above Bonneville Dam. If warranted and after consultation with NMFS and USFWS, the Action Agencies shall develop and implement methods of control that may include reducing the populations of these predators.

Gulls, terns, pelicans, common mergansers, and other birds consume juvenile salmonids in the Columbia and Snake rivers (Meacham and Clark 1979 in Bevan et al. 1994, Ruggerone 1986 in Bevan et al. 1994, Bevan et al. 1994, and Wood 1987). The combined effect of this predation on listed stocks is unknown, but the increasing colonies of Caspian terns, California and ring-billed gulls, and white pelicans could have a substantial effect on limited fish populations. A study of gull predation in the upper Columbia River in 1986 indicated that 2% of the juvenile salmonids passing Wanapum Dam were consumed. Additional information on consumption rates, migration patterns, and the ultimate effect on fish populations is needed before sound management decisions can be made. This effort must be coordinated with ongoing avian control activities in the Columbia River estuary and with the USDA Wildlife Services and USFWS.

Action 103: The Action Agencies shall quantify the extent of predation by white pelicans on juvenile salmon in the McNary pool and tailrace. A study plan shall be submitted to NMFS by September 30, 2001, detailing the study objectives, methods, and schedule. Based on study findings, and in consultation with USFWS and NMFS, the Action Agencies shall develop recommendations and, if appropriate, an implementation plan.

Up to six dozen white pelicans have been observed along the Oregon shore a short distance below the McNary Dam juvenile facility during the spring migration. Additional data are needed to determine the extent of pelican predation on salmonids.

Action 104: The Action Agencies shall recover PIT-tag information from predacious bird colonies and evaluate trends, including hatchery-to-hatchery and hatchery-to-wild depredation ratios.

Evaluation of this information, when combined with bird and fish behavioral information, will help managers develop a better understanding of issues such as prey selection, stock-specific vulnerability, and potential long-term predation effects on specific listed stocks, including effectiveness of management actions to reduce predation by birds.

Action 105: The Action Agencies shall develop a pilot study to assess the feasibility of enhancing the function of ecological communities to reduce predation losses and increase survival in reservoirs and the estuary.

The pilot study should include a combination of hydrosystem operations, enhancement of mainstem and estuarine habitat, and directed fishery management options. Information for the near-term studies would serve as the basis for a longer-term effort to enhance habitat and community function within the mainstem corridor. Issues to evaluate include natural and manmade habitat alterations, reservoir level fluctuations during predator spawning seasons, sport fish management options, and sediment and nutrient transport.

Action 106: The Action Agencies, in coordination with NMFS, shall investigate marine mammal predation in the tailrace of Bonneville Dam. A study plan shall be submitted to NMFS by June 30, 2001, detailing the study objectives, methods, and schedule.

From 1990 through 1993, the annual incidence of marine mammal tooth and claw abrasions on fish examined at the Lower Granite adult trapping facility ranged between 14% and 19% for spring-summer chinook, and between 5% and 14% for steelhead. The proportion of adults examined that had open wounds ranged from 5% to 6% for chinook and 1% to 6% for steelhead (Harmon et al. 1994). The prevalence of these abrasions was generally higher during the earliest portion of the run, with reported incidence of 30% on the chinook in 1993 (Harmon et al. 1995). Based on the severity of the observed signs, NMFS speculates that many fish injured by marine mammals die before reaching this project. Marine mammal predation occurs in the near-ocean, estuary, and lower Columbia River up to Bonneville Dam. On many occasions, California sea lions have been observed feeding on adult salmon (primarily spring chinook) near the fishway entrances below Bonneville Dam. While predation by marine mammals in the lower river is not a result of the FCRPS, site-specific predation immediately below FCRPS dams (i.e., Bonneville) is, in part, a result of the presence and operation of the dam. Evaluation of this predator activity should include development of remedial methods that may include relocation or lethal removal. This effort must be coordinated with ongoing marine mammal control activities in the Columbia River estuary and near-ocean.

9.6.1.6 Adult Passage and Research

The actions described in this section represent the best starting point for planning future capital investment in measures to improve the survival of adult salmon migrating past the Corps mainstem FCRPS dams. The specific list of measures to be implemented, their priority, and the method of evaluation will be developed in the 1- and 5-year plans described in Section 9.4. As determined through the annual planning process in Section 9.4, other combinations of measures may also be deemed sufficient to meet the juvenile and adult performance standards and, thus, will avoid jeopardy.

In many cases, the measures described are limited to prototype or facility development and evaluation and include statements that the Action Agencies are expected to implement the results “as warranted.” The intent of the measures in these cases is to proceed to implementation upon completion of testing, unless the results of the evaluation present additional problems that have to be addressed through further testing.

9.6.1.6.1 Adult Fish Passage Strategy. A primary objective of this RPA is to maximize direct survival of upstream migrating adult fish at the Federal hydrosystem dams with passage facilities and to minimize indirect (prespawning) mortality in intervening reservoirs and upstream of the hydrosystem. To achieve this objective, the RPA expands investigations of adult passage problems in order to identify direct and indirect mortality-related problems and implement needed improvements. The following research and configuration action items are meant to accomplish six objectives:

- Reduce site-specific and cumulative delay (including fallback over spillways, fallback through turbines and intake screen/bypass systems, and fallback/fallout from fishways).
- Identify correctable project-related direct mortality factors.
- Enhance headburn investigations.
- Protect downstream migrating adult steelhead post-spawners (kelts).
- Improve auxiliary water system diffusers to minimize risk of potential failure (and risks to adult migrants).
- Identify factors related to prespawning mortality of fish that have passed through the FCRPS hydrosystem.

9.6.1.6.2 Studies and Measures (including Research, Monitoring, and Evaluations)

Action 107: The Action Agencies shall conduct a comprehensive evaluation to assess survival of adult salmonids migrating upstream and factors contributing to unaccounted losses.

Broad objectives for such studies may include the following:

- Evaluate survival rates between dams and through the system.
- Partition interdam losses by factor.
- Assess causal mechanisms associated with losses.

- Assess reproductive success, including causal mechanisms associated with reduced reproductive success, if any.
- Identify measures, as appropriate, to address factors affecting passage, survival, and reproductive success.

More specific investigations may include the following:

- Fallback (operational related versus other factors)
- Passage delay (relative to project and reservoir operations, including turbines, spill, and peaking)
- Injury (resulting from passage, marine mammals)
- Headburn
- Homing/straying
- Mainstem spawning
- Tributary turnoff and spawning
- Effect of TDG supersaturation
- Effect of temperature (including use of cool water microhabitat)
- Energy expenditure
- Susceptibility to disease
- Unaccounted incidental mortality associated with harvest
- Cumulative effects (synergism)

Action 108: The Corps and BPA shall conduct a comprehensive evaluation to investigate the causes of headburn in adult salmonids and shall implement corrective measures, as warranted.

While the exact cause of headburn remains unknown (NMFS 2000e), Elston (1996) conducted clinical evaluations of fish with typical headburns from Lower Granite Dam and suggested that headburns were caused by mechanical abrasion and laceration, rather than by necrosis associated with subcutaneous emphysema from GBT. NMFS monitoring at Lower Granite Dam from 1993

through 1999 showed that the rate of incidence of adult spring chinook with headburn ranged from 0% to 9.8% (NMFS 2000e). Bjornn et al. (1995) found in 1993 that of 66 radio-tagged chinook salmon with head scrapes or injuries, 38% did not migrate to known spawning areas and were classified as possible prespawning mortalities. Thus, headburn could be related to a chinook prespawning mortality rate of approximately 2%. This was calculated by multiplying the average of the monitored incidence range (4.9%) times the percentage of head-injured chinook that did not migrate (38%) [$4.9\% \times 38\% = 1.9\%$]. This implies that corrective measures could potentially boost adult spring chinook survival as high as 2% on average.

An example of corrective measures would be investigating the potential benefit of replacing existing spill gate closure (sill) seals, in conjunction with improved connector designs, which are benign to large fish that fall back through the spillway. It is possible that this could reduce the incidence of headburn injury.

Action 109: The Corps shall initiate an adult steelhead downstream migrant (kelt) assessment program to determine the magnitude of passage, the contribution to population diversity and growth, and potential actions to provide safe passage.

Data acquired through sampling in the Lower Granite and Little Goose Dam bypass systems during the peak fallback season of April through June 2000 were used to arrive at a preliminary estimate of 16,745 steelhead kelts present in the Lower Snake River at Lower Granite Dam during the study period (Evans and Beaty 2000). This abundance level represents 22% of the 74,440 adult steelhead counted passing Lower Granite in 1999 (Fish Passage Center 2000, counts for 1999). Theoretically, reconditioning and/or kelt downstream transportation could significantly increase the likelihood of a second spawning opportunity for many of these fish. Also, their downstream in-river survival could be increased by simply providing more effective alternative passage routes to avoid the higher mortality associated with turbine passage.

Evaluations should be conducted to review available literature and develop pilot testing regarding reconditioning of kelts. The Corps will assess and conduct a short-term holding evaluation at a project site where kelt are more abundant and initiate a kelt transportation pilot study as a possible means of reducing dam passage mortality. The Corps will evaluate kelt passage associated with the RSW at Lower Granite Dam (described in Section 9.6.1.4), which will be prototype-tested in 2001 in the context of juvenile fish passage. The Corps will synthesize these work elements and report the magnitude of kelt passage, effects of passage on survival, and potential actions to improve survival, if deemed appropriate, to NMFS' Regional Forum by September 2003.

Action 110: The Corps shall use information from previous and ongoing investigations regarding the problem of adult steelhead holding and jumping in the fish ladders at John Day Dam, develop a proposed course of action, and implement it, as warranted.

This problem has been investigated in a fragmented manner for years. A more detailed collation of cumulative work to date is required, combined with an assessment of alternatives.

Action 111: The Corps shall investigate and enumerate fallback of upstream migrant salmonids through turbine intakes at all lower Snake and lower Columbia River dams. The Corps shall implement corrective measures to reduce turbine mortality, as warranted.

Between 1996 and 1998, fallback rates for spring/summer chinook were between 11 to 15% and 9 to 13% at The Dalles and John Day dams, respectively. In 1996 and 1997, fallback rates for steelhead were between 7 to 10% and 11 to 13% at The Dalles and John Day Dams, respectively (NMFS 2000e, p 88). Keefer and Bjornn (1999) used radio-tagged adults known to have passed Bonneville Dam in 1996 to estimate survival to tributaries or to the top of Priest Rapids Dam. Steelhead and spring/summer chinook salmon that did not fall back over any dam had survival rates that were 3.0 to 5.4% higher than fish that did fall back. Mendel and Milks (1996) estimated that the fallback of fall chinook salmon at Lower Granite Dam was 16 to 39% in 1993 and 30 to 41% in 1992. They estimated fall chinook fallback mortality at 26 and 14% in 1993 and 1994, respectively, for fish that fell back through one or more of the four lower Snake River dams. This higher mortality for fall chinook occurred during periods of no spill, when fallback was assumed to have been through turbines. This information on the rate of fallback and the reduced survival due to fallback can be used to estimate the theoretical gain in survival that could be achieved by corrective measures. For spring/summer chinook, multiplying the 11% observed average rate of fallback at John Day Dam between 1996 and 1998 times the 4.2% higher survival rate, on average, observed for fish that did not fall back implies a potential survival rate increase of .5% [$11\% \times 4.2\% = .46\%$]. For steelhead, multiplying the 12% observed average rate of fallback at John Day Dam between 1996 and 1997 times the 4.2% higher survival rate, on average, observed for fish that did not fall back implies a potential survival rate increase of .5% [$12\% \times 4.2\% = .50\%$]. For fall chinook, multiplying the 28% estimated average fallback rate at Lower Granite in 1993 times the 26% estimated mortality rate for fish that fell back through one or more of the Lower Snake dams in 1993 implies a potential survival rate increase of 7% [$28\% \times 26\% = 7.3\%$].

Corrective measures to reduce the mortality associated with fallback may include installation of extended-length screens (where feasible), extending the period during which the intake screens and juvenile bypass system are in operation, and modifying operations. Study plans, recommendations, and a schedule for accomplishing this action will be developed through the annual planning process.

Action 112: The Corps shall investigate ways to provide egress to adult fish that have fallen back into juvenile collection galleries and primary dewatering facilities at Ice Harbor and McNary dams. The Corps shall either install structural, or implement operational, remedies to minimize delay and injury of fish that fall back, as warranted.

Prespawn, summer-run steelhead are abundant near McNary Dam during the late fall and early winter months. Fallback through the juvenile bypass system at McNary Dam can exceed 50 steelhead per day before screen removal on December 15 (Paul Wagner, Washington Department of Fish and Wildlife, pers. comm.). These fish accumulate in the juvenile bypass system, and many are delayed for protracted periods. Timely and safe egress alternatives for these fish must be identified.

Action 113: The Corps shall investigate measures to reduce adult steelhead and salmon fallback and mortality through the Bonneville Dam spillway. A final report shall be submitted to NMFS stating the findings of these investigations and recommending corrective measures. Potential remedies shall be included in the annual planning process.

Keefer and Bjornn (1999) estimate, based on radiotelemetry, that ladder counts at Bonneville Dam are overcounted by 13.5 to 19.3% for spring/summer chinook salmon from 1996 through 1998, by 4.7% to 8.2% for steelhead from 1996 through 1997, and by 12.6% for sockeye in 1997 when fallback and reascension are taken into account. Fallback rates at Bonneville Dam were 12 to 15% for spring/summer chinook (1996 to 1998), and 5 to 10% for steelhead (1996 to 1997). Assigning mortality associated with fallback to dam operations or behavior is difficult because some fish may have overshot and are returning to lower river tributaries. Bjornn et al. (1999) observed a fallback mortality of 8% for sockeye salmon at Bonneville Dam (a species with no spawning below Bonneville Dam). Keefer and Bjornn (1999) used radio-tagged fish known to have passed Bonneville Dam in 1996 to estimate survival to tributaries or the top of Priest Rapids Dam. Steelhead and spring/summer chinook salmon that did not fall back over Bonneville Dam had survival rates that were 3.8 to 5.2% higher than fish that did fall back (NMFS 2000e). Conceivably, corrective operations or facility changes which significantly reduce fallback at Bonneville Dam could increase the survival rate of spring/summer chinook to Lower Granite Dam by 0.7% [$15\% \times 4.5\% = 0.68\%$] and of steelhead by 0.5% [$10\% \times 4.5\% = 0.45\%$]. These estimates of potential survival increases are calculated by multiplying the fallback rate observed at Bonneville Dam in 1998 for spring/summer chinook, and for steelhead in 1997, times 4.5%, which is the average higher survival rate to Lower Granite Dam for adults that did not fall back at Bonneville Dam. Adult fallback through the Bonneville Dam spillway has been a long-standing concern. Further investigation is needed to determine factors affecting fallback and identify potential measures to reduce it.

Action 114: The Corps shall examine existing fish-ladder water temperature and adult radio-telemetry data to determine whether observed temperature differences in fishways adversely affect fish passage time and holding behavior. If non-uniform temperatures are found to cause delay, means for supplying cooler water to identified areas of warmer temperatures should be developed and implemented in coordination with the annual planning process.

Data collected by the Corps show that water temperatures at various sections of the John Day fishways differ from 1° to 4°C (34° to 39°F) at times. Effects of such differences on fish passage are unknown.

Action 115: The Corps and BPA shall conduct a comprehensive depth and temperature investigation to characterize direct mortality sources at an FCRPS project considered to have high unaccountable adult losses (either from counts and/or previous adult evaluations).

Previous radiotelemetry investigations have been two-dimensional and have attempted to characterize passage routes and timing of successfully passing fish. This study will also attempt to focus on those fish that do not successfully pass and determine whether a consistent source of mortality can be identified and corrected.

Action 116: The Corps shall investigate adult fish delay and fallback at ladder junction pools and implement remedies to reduce this problem, as warranted.

A large percentage of fish fall back from fishway junction pools at each FCRPS and other hydro projects studied to date. Cumulative delay and influence on prespawning mortality could be substantial. Modified hydraulic conditions and other possible remedies, coupled with behavior responses in these areas, may reduce this delay.

Action 117: The Corps shall evaluate adult count station facilities and rehabilitate where necessary at all projects to either minimize delay of adults or minimize counting difficulties that reduce count accuracy.

Some FCRPS hydro project fishway counting stations need design improvement to reduce delay. Cumulative delay and influence on prespawning mortality could be substantial. Rehabilitating counting stations could also improve the accuracy of adult fish counts.

Action 118: The Corps shall develop and implement a program to better assess and enumerate indirect prespawning mortality of adult upstream-migrating fish. Such mortality may be due to, or exacerbated by, passage through the FCRPS hydro projects. If measures are identified which will reduce the unaccountable adult loss rate and/or the prespawning mortality rate, the Corps shall implement these measures as warranted. The program should also enhance efforts to enumerate unaccountable losses associated with tributary turnoff, harvest, or other factors in FCRPS mainstem reservoirs and upstream of FCRPS projects.

Adult radiotelemetry has been used to estimate the survival of spring/summer chinook salmon from Ice Harbor Dam to the spawning ground or hatcheries. Bjornn et al. (1995) estimated that survival from Ice Harbor Dam to the spawning ground or hatcheries to be 54% in 1991 and 77% in 1993. In these same studies, survival from Ice Harbor Dam to Lower Granite Dam was

estimated to be 81% in 1991 and 86% in 1993. Calculating the difference in these estimated survival rates from Ice Harbor Dam to Lower Granite Dam and Ice Harbor Dam to spawning ground/hatcheries implies theoretical adult loss from Lower Granite Dam to spawning ground/hatcheries of 27% (1991) and 9% (1993) [$81\% - 54\% = 27\%$; $86\% - 77\% = 9\%$]. While further studies will be needed to resolve the accuracy and cause of these preliminary observations, the significance of this level of adult loss above Lower Granite Dam to the prospect of recovery cannot be overstated. Furthermore, mere arrival at the spawning ground does not guarantee spawning success. If spawning success is diminished during upstream passage through the FCRPS, these adult loss estimates are conservative.

The program called for in this action should include studies to assess the effects of upstream migration of adults through the hydrosystem (including the thermal environment through which they must migrate) on their overall fitness and spawning success, including energy budgets, ability to complete spawning behavior, and successful production of quality gametes. Currently, little work has been completed to assess the magnitude and breadth of prespawning mortality of adult migrants, especially upstream of the FCRPS hydrosystem. New methods of assessment should be evaluated, including the investigation of long-term PIT-tag retention in maturing salmonids. The investigations are expected to identify measures at FCRPS hydro projects, and possibly in tributaries, that will lead to reductions in prespawning mortality throughout the Columbia River basin.

Action 119: The Corps shall ensure that alterations to fish ladders and adult passage facilities to accommodate Pacific lamprey passage do not adversely affect salmonid passage timing and success.

Followup evaluations are needed as a precaution.

9.6.1.6.3 Adult Fishway Operating Criteria. The Corps' annual fish passage plan stipulates operating criteria for FCRPS hydro project adult fishways. Where this criterion is not satisfied, incremental adverse effects to adult migrants (such as delay) may occur. Actions to enhance compliance with fishway criteria include auxiliary water system assessments and upgrades. Other actions address the issue of inadequate fishway entrance weir submergence during low tailwater elevations.

Action 120: The Corps shall develop improved operations for adult fishway main entrances at FCRPS dams so that the best possible attraction conditions are provided for adult migrants, both at the four Columbia River hydro projects and the four lower Snake hydro projects (where reservoir elevations are held near MOP). The Corps shall report the findings of fishway entrance flow-balancing investigations in a report to NMFS by the end of 2001 and shall continue to work through FPOM to evaluate and implement, as warranted, structural changes to satisfy fish passage plan fishway entrance criteria.

Current Fish Passage Plan fishway entrance criteria cannot be satisfied at some entrances at many FCRPS hydro project fishways during low tailwater periods. Concurrently, some entrances pass appreciably more attraction flow than other entrances at the same project. The Corps should, on an interim basis, conduct hydraulic evaluations and make operational changes to increase attraction flows at entrances not presently meeting fishway criteria at all tailwaters during the adult passage season. The Corps should also continue to investigate various operations (such as closing floating orifice gates or other operational alternatives) to improve adult entrance and passage conditions.

9.6.1.6.4 Reliability Enhancement. FCRPS hydro project fishways must operate in the optimum manner during fish passage periods to minimize the risk of injury and mortality. Actions to increase reliability include fishway assessments to identify aging facilities (and components) in need of replacement or redesign, improved debris handling capability, and emergency backup auxiliary water capabilities (related to satisfying fishway entrance attraction water supply criteria).

Action 121: The Corps shall develop and maintain an auxiliary water-supply, emergency-parts inventory for all adult fishways where determined necessary, in coordination with NMFS.

Emergency auxiliary water supplies are needed to maintain fishways within optimum criteria for passage in the event of turbine, pump, electrical, debris management, or water-control system component failures.

Action 122: The Corps shall continue design development and, subsequently, construct an emergency auxiliary water supply system at The Dalles Dam's east ladder.

The Dalles adult fishways pass the second-highest number of adult fish of any FCRPS hydro project. With aging auxiliary water turbines, generators, and transformers, there is an increasing risk of faulty adult fishway performance during primary passage periods. Emergency backup auxiliary water is vital to attract fish into the fishways, if a primary fishwater turbine failure occurs.

Action 123: The Corps shall continue to investigate alternatives to dewater adult auxiliary water system floor diffusers for inspection at The Dalles adult fishway powerhouse collection channel. The Corps shall implement design and construction of needed changes, as warranted.

Leaking fishway entrance gates at The Dalles Dam make it impossible to dewater the powerhouse adult collection channel to inspect aging facilities such as add-in diffusers. Several years ago, numerous adult salmon passing through diffusers were killed. This action will minimize the chance of the recurrence of this problem and reduce leakage from the auxiliary water system.

Action 124: The Corps shall investigate methods to provide additional emergency auxiliary water to The Dalles Dam north fishway when the normal auxiliary water supply is interrupted.

If the existing Northern Wasco County PUD turbine at the north shore fishway has a prolonged outage, gravity auxiliary water would have to be provided for fishway attraction flow. The current rock conveyance channel is deteriorated and unstable. This additional water could also be used as a source of auxiliary water to supply the second fishway entrance if adult passage studies indicate the entrance is needed.

Action 125: The Corps shall develop and implement an automated monitoring and alarm system at appropriate FCRPS projects, as determined in the NMFS Regional Forum, to monitor changes in head differential remotely between the primary auxiliary water supply conduits/channels and the adult collection channels and to minimize diffuser damage due to excessive differentials. The Corps shall ensure that diffuser gratings for all auxiliary water supply systems are securely fastened. The Corps shall work through FPOM to develop a monitoring program for inspecting diffuser gratings and grating fasteners.

Implementation of this action would help avoid undetectable diffuser failures and potentially significant adult fish losses. In the interim, the Corps will work through the FPOM coordination team to develop early detection measures and include these in the annual Fish Passage Plan before the 2001 fish passage season.

9.6.1.6.5 Fishway System Assessments. Additional fishway assessments are needed to address, in a more comprehensive manner, fishway systems at some FCRPS hydro projects that have aging facilities or ongoing, unresolved problems. These assessments will lead to a well-defined list of corrective measures.

Action 126: The Corps shall initiate an investigation and prepare a report on the Bonneville First Powerhouse Bradford Island and Cascade Island adult fishway auxiliary water system by the end of 2001. In the report, the Corps shall identify measures that will improve or replace aging components, thereby enhancing current and long-term performance and reliability.

The need for design changes and improvements will be evaluated, particularly with respect to elevated dissolved gas levels in the auxiliary water supply systems. Report recommendations should be implemented, as warranted.

Action 127: The Corps shall continue its investigation of the Bonneville Second Powerhouse adult fishway auxiliary water system and shall identify measures to satisfactorily address emergency backup auxiliary water needs.

Bonneville Second Powerhouse adult auxiliary water facilities failed in 1997 during the peak of the adult fall chinook and steelhead migrations. This action is intended to ensure that this does not occur again.

Action 128: The Corps shall initiate an engineering study to evaluate existing limitations relating to its inability to satisfy fish passage plan operating criteria at the John Day Dam north shore ladder.

The study scope should also assess backup auxiliary water system (AWS) needs, reliability, or enhancement design improvements and upgrade options for the AWS system. The Corps will implement corrective measures as warranted.

Action 129: The Corps shall complete adult fishway auxiliary water supply evaluations at each lower Snake River hydro project and implement corrective measures as warranted.

The objective of this measure is to ensure compliance with fishway entrance criteria, optimize emergency auxiliary water backup provisions, and ensure long-term reliability.

9.6.1.7 Water Quality

9.6.1.7.1 Water Quality Strategy. In developing the biological opinion, NMFS, in coordination with EPA, USFS, and the Action Agencies (the Corps, BOR, and BPA), has considered the respective ecological objectives of the ESA and the Clean Water Act (CWA). In many instances, actions implemented for the conservation of ESA-listed species will also move toward attainment of water quality standards (e.g., reducing TDG and temperature). The overlap of statutory purpose is extensive; however, there are additional actions that are appropriate in a water quality plan, but that are nonessential for the survival and recovery of the listed species. Thus, such actions are not required components of the ESA RPA. Further, the water quality plan is likely to require lengthy study and implementation exceeding the duration of this biological opinion.

Appendix B charts a course for development of a water quality plan for the mainstem Columbia and Snake rivers to address CWA objectives. The scope of the plan is broader than the FCRPS and would include additional actions to improve mainstem water quality by reducing TDG and temperature. Some of these actions are expected to be undertaken by entities other than the Action Agencies. Although Appendix B is not itself a water quality plan, it suggests the procedure for development of a plan and identifies actions the plan would likely contain to move toward attainment of water quality standards for the FCRPS.

Appendix B refers to items in Section 9.6.1.7.2 as a nucleus of actions for the water quality plan. These actions are essential for the survival and recovery of the listed species and, thus, are required components of the RPA that also serve to improve water quality by reducing TDG and water temperature.

Appendix B also identifies actions for the FCRPS that further CWA objectives, but that are not also called for in the ESA RPA. These long-term actions for water quality improvements are listed in Table B-3 of the Appendix. These are studies to investigate additional measures to reduce TDG and temperature that may be considered for implementation. These studies are appropriate as ESA conservation measures that will require further ESA consultation when they are developed, analyzed, and proposed for implementation.

Currently, voluntary spill for fish passage occurs at dams up to the TDG level of 120% in the project tailrace, or 115% TDG in the next downstream project forebays, as allowed by special variances to state and Tribal water quality standards. However, spill for fish passage that results in exceedances of the 110% gas standard is considered an interim strategy in the sense that the long-term goal is to keep TDG levels within water quality standards.

Accordingly, the 1995 FCRPS Biological Opinion mandated initiation of the DGAS. This multi-year comprehensive study by the Corps investigated and extended understanding of gas absorption and reduction associated with spill at Columbia and Snake river hydro projects. It also investigated short- and long-term operational and structural gas abatement alternatives, which resulted in installation of spillway flow deflectors at both John Day and Ice Harbor spillways. These improvements increased project survival at both sites and improved water quality during both voluntary and involuntary spill periods. The DGAS also developed numerical models to fully investigate the hydrosystem response to structural and/or operational changes. One outcome of DGAS was that no structural action was identified that would reduce TDG levels to meet the state or Tribal water quality standards without threat of adverse effects to passing fish.

To assess the feasibility of reducing TDG to the 110% standard while still meeting the survival objectives of listed salmon, EPA, NMFS, USFWS, and the Federal Action Agencies commit to continued efforts to identify water quality improvement actions (see Appendix B). These efforts will lead to decisions on whether structural or operational changes exist that will allow FCRPS projects to achieve both fish passage and water quality objectives, or to encourage changes in non-Federal Columbia River basin projects that have a cumulative effect of reducing TDG levels systemwide. Information developed from these studies may also provide a basis for future decisions concerning beneficial use and water quality criteria revisions. Such decisions will result from a coordinated effort between EPA and NMFS and discussions with states, Tribes, and other interested parties. The EPA, NMFS, USFWS, and the Federal Action Agencies will continue to work toward implementing a combination of actions that benefit both fish survival and water quality.

Part of the decision-making process to evaluate the structural and operational changes necessary to meet the 110% TDG standard will be based on a review of the existing data collected since the release of the NMFS 1995 Biological Opinion (see Section 6.2.6.1.1 for a summary of the risk assessment for the spill program described in the NMFS 2000 Biological Opinion). GBT in juvenile salmonids is observed at all gas supersaturation levels, but the overall incidence and

severity is low at FCRPS projects when managing fish passage spill to 115% to 120% TDG variance.

Without physical modifications to the dams beyond those that are presently under way, the long-term TDG goal cannot be attained between April and August at and between the eight mainstem FCRPS dams. This is a result of the need to rely on spill to safely pass juvenile salmon around those dams. A similar issue exists with Dworshak Dam, where, in some circumstances, spill is necessary to contribute to the attainment of spring and summer flow objectives for salmon migration and water temperature standards in the Clearwater and lower Snake rivers. In the near term, therefore, it will be necessary to conduct spill operations that cause exceedances of the 110% TDG gas standard. The Corps will take the actions necessary to implement the spill operation called for in this biological opinion, including spill in accordance with the special TDG conditions set forth below. NMFS will provide technical assistance, as necessary, to support the Corps' actions.

Special TDG Conditions for Juvenile Fish Passage. At the eight Columbia and Snake river mainstem hydro projects, and consistent with state and Tribal water quality variances, spill will be reduced as necessary when the average TDG concentration of the 12 highest hourly measurements per calendar day exceeds 115% of saturation at the forebay monitor of any Snake or lower Columbia river dam or at the Camas/Washougal station below Bonneville Dam. Spill will also be reduced when the 12-hour average TDG levels exceed 120% of saturation at the tailrace monitor at any Snake River or lower Columbia River dams or Dworshak Dam. Spill will also be reduced when instantaneous TDG levels exceed 125% of saturation for any 2 hours during the 12 highest hourly measurements per calendar day at any Snake, Clearwater, or lower Columbia river monitor.

The water quality plan in Appendix B includes the following basinwide goals for TDG and temperature. NMFS, EPA, and the Action Agencies commit to work toward these goals. They recognize, however, that reaching the goals may take more time than the duration of this biological opinion and that exceedances may, nevertheless, occur.

Total Dissolved Gas Goal. The long-term TDG goal (10 to 15 years) is to reach the 110% TDG standard in all critical habitat in the Columbia and Snake River basins while taking actions to recover listed species in the basins. For anadromous fish, achieving the goal would mean fish passage survival levels are consistent with the performance standards for the mainstem projects.

This goal is intended to guide operating and capital improvement decisions relating to TDG created during periods of spill. A systemwide approach is needed to address gas generated at mainstem projects where fish are present and at upstream facilities (i.e., outside the current range of listed salmon) in both the U.S. and Canada, the five PUD dams on the Columbia River between the Snake River and Chief Joseph Dam, and the Hells Canyon Complex on the Snake River. Some exceptions are noted in the ability to meet the state and Tribal TDG standard.

Water Temperature Goal. The long-term goal for water temperature is standard attainment in all critical habitat in the Columbia and Snake River basins. In the mainstem Columbia and Snake rivers, attainment of the temperature standard is very complex, due to a number of interrelated factors that affect water temperatures at certain times of the year and to the limited ability to alter water temperature in the mainstem. In the tributaries, attainment of the temperature standard is also complex, due to many of these same factors and the long time needed to realize the temperature benefits of remedial actions (such as riparian restoration). Therefore, in the near term, working with the state and/or Tribe with relevant regulatory authority, the interim goal is to move toward attaining the standard. Establishing TMDLs is expected to significantly promote progress toward the interim goal.

To ensure progress toward the long-term goals, the Corps, BOR, and BPA will also work with NMFS, USFWS, EPA, the Columbia River Tribes, and the states of Washington, Oregon, Idaho, and Montana through an adaptive management process as a part of the water quality plan described in Appendix B.

Perhaps none of the ongoing forums and/or water quality protection activities will provide the organizational structure desired to fully integrate the activities of the water quality plan as described in Appendix B. Therefore, final development and implementation of the water quality plan could be accomplished through reformulation of the Water Quality Team, consisting of senior policy analysts and supported by technical staff from Federal agencies, states, Tribes, and non-Federal entities.

9.6.1.7.2 *Current and Near-term Actions and Studies*

Total Dissolved Gas Measures

Action 130: The Corps shall complete its DGAS by April 2001. The results of this study will be used to guide future studies and decisions about implementation of some long-term structural measures to reduce TDG.

The DGAS was initiated in 1994 to examine potential methods to reduce TDG produced by spillway operations at the Corps' eight mainstem Snake River and Columbia River hydropower dams. The feasibility-level DGAS report is expected to be completed in spring 2001. The findings from this study have to be examined and discussed with interested parties in the region to guide future studies before making long-term implementation decisions about gas abatement alternatives.

Action 131: The Action Agencies shall monitor the effects of TDG. This annual program shall include physical and biological monitoring and shall be developed and implemented in consultation with the Water Quality Team and the Mid-Columbia PUDs' monitoring programs.

At a minimum, the physical monitoring components of this plan should include placement of physical TDG monitors in the tailraces and forebays of all lower Snake River and lower Columbia River dams, and daily recording of TDG data on the CROHMS database. This program should also include QA/QC components, including redundant and backup monitors at as many locations as the Water Quality Team determines necessary, calibration of monitoring equipment at least every 2 weeks, enough funding for spot-checking monitoring equipment during the fish passage season (number determined pre-season by the Water Quality Team), an error checking, correcting, and recording function for CROHMS data, and daily data reporting. The QA/QC components should be reviewed annually and modified as improved information and techniques become available. The annual review should be conducted by the Action Agencies in coordination with the Water Quality Team.

At a minimum, the biological monitoring components will include smolt monitoring at selected smolt monitoring locations, adult monitoring at Bonneville and Lower Granite dams, and daily data collection and reporting.

Action 132: The Action Agencies shall develop a plan to conduct a systematic review and evaluation of the TDG fixed monitoring stations in the forebays of all the mainstem Columbia and Snake river dams (including the Camas/Washougal monitor). The evaluation plan shall be developed by February 2001 and included as part of the first annual water quality improvement plan. The Action Agencies shall conduct the evaluation and make changes in the location of fixed monitoring sites, as warranted, and in coordination with the Water Quality Team. It should be possible to make some modifications by the start of the 2001 spill season.

In past years, TDG monitoring in tailraces at mainstem dams produced variable results associated with differences in dam operations. Operational differences caused the proportion of spill and turbine-discharged water to change at measuring sites. This problem can be substantial and often causes unreliable extrapolation of TDG levels to downstream locations where spill and turbine flows are fully mixed. For this reason, TDG measurements in both forebays and tailraces have been monitored as part of the NMFS spill program. Forebay TDG monitors typically are located on the pier noses and other portions of hydro projects near turbine intakes or spillways. The tailrace stations, however, are located at various distances downstream from the hydro projects where spillway and powerhouse flows are mixed. One obvious deviation from the normal forebay monitoring location is the Camas/Washougal site. This site was chosen as a surrogate forebay monitor location for the river reach below Bonneville Dam because available data indicated that spill and powerhouse flows were normally well mixed at this point in the river.

In-season management of biological opinion spill to improve juvenile fish survival relies on the physical TDG and the biological GBT monitoring programs. Based on comments received on the draft opinion and a recent Corps review of possible biases in TDG monitoring data from TDG fixed forebay monitors at dams on the mainstem Columbia and Snake rivers, NMFS

believes some sampling locations may have to be altered to provide a more representative measure of TDG in the water mass passing through the dams.

Action 133: As part of DGAS, the Corps shall complete development of a TDG model to be used as a river operations management tool by spring 2001. Once a model is developed, the applications and results shall be coordinated through the Water Quality Team. The Corps shall coordinate the systemwide management applications of gas abatement model studies with the annual planning process, the Transboundary Gas Group, the Mid-Columbia Public Utilities, and other interested parties.

TDG, caused by large volumes of water spilling over dams, can result in injury or mortality of juvenile salmonids. Since the 1960s, increased hydraulic capacity at powerhouses of mainstem projects, increased water storage, and structural modification to spillways have substantially reduced this problem. High levels of dissolved gas have, however, been measured under some river conditions even in recent years, such as during periods of involuntary spill. Development and continued refinement of a systemwide TDG model would assist with in-season management of involuntary spill.

Action 134: The Corps shall continue the spillway deflector optimization program at each FCRPS project and implement it, as warranted. The Corps and BPA shall conduct physical and biological evaluations to ensure optimum gas abatement and fish passage conditions. Implementation decisions will be based on the effect of spill duration and volume on TDG, spillway effectiveness, spill efficiency, forebay residence time, and total project and system survival of juvenile salmon and steelhead passing FCRPS dams.

The spillway deflector optimization program shall have the following objectives:

- Increase juvenile fish passage survival at FCRPS projects by increasing the allowable spill discharge up to the TDG special condition gas cap level during voluntary spill periods (as defined by the NMFS annual spill program in Section 9.6.1.4.4).
- Decrease TDG levels during both voluntary and involuntary spill periods.
- Considering both juvenile and adult fish passage criteria, develop spill patterns that improve juvenile survival, reduce delay of juvenile salmon in forebays, optimize juvenile egress from tailraces, and provide good adult passage conditions downstream of fish ladder entrances.

Action 135: The Corps shall include evaluations of divider walls at each FCRPS project in the spillway deflector optimization program. Design development and construction

of divider walls would begin only after coordination within the annual planning process, and only if warranted.

Design development of divider walls is an option under consideration to potentially reduce entrainment of powerhouse flow into spillway flow. The degree to which powerhouse flow in the tailrace mixes laterally with spillway flow is an unresolved issue. Specifically, the extent to which powerhouse flow TDG levels are increased or decreased in the tailrace may be affected by mixing with water that has passed through the spillway. Additional investigation is required to increase understanding of this issue. Optimum deflector design development will include a full investigation of powerhouse flow entrainment with spillway flow and TDG uptake downstream of each project. Construction at an FCRPS project will be included in the deflector optimization program, if warranted, for the purpose of attaining water quality and fish survival benefits.

Action 136: The Corps shall continue to develop and construct spillway deflectors at Chief Joseph Dam by 2004 to minimize TDG levels associated with system spill.

To the extent feasible, the Corps, BOR, and BPA will treat Grand Coulee and Chief Joseph dams as a composite project to reduce the incidence of spill and TDG below Grand Coulee and other system projects by spilling proportionately more at Chief Joseph and shifting electrical load to Grand Coulee Dam.

Action 137: The Corps shall investigate TDG abatement options at Libby Dam, including the installation of spillway deflectors and/or additional turbine units. The Corps shall construct gas abatement improvements at Libby on the Kootenai River, as warranted, to reduce TDG levels below the project.

Through the use of numerical TDG modeling, the Corps should assess projected gas abatement benefits at Libby Dam on a site-specific and systemwide basis to improve the probability of refill and, if spill occurs, to avoid TDG levels above state water quality standards.

Action 138: The Corps shall continue to investigate RSWs, in conjunction with extended spillway deflectors, as a means of optimizing safe spillway passage of adult steelhead kelts and juvenile migrants.

While these prototype RSW evaluations continue, they have the potential to incrementally reduce both spill discharge and TDG levels downstream. Thus, development of RSWs (and other surface bypass concepts) have the potential to integrate implementation of actions to meet both ESA and CWA requirements. See also Section 9.6.1.4.5, Juvenile Fish Passage Studies.

Action 139: The Corps shall investigate TDG abatement options at Dworshak Dam and implement options, as warranted, in coordination with the annual planning process.

Implementation of TDG abatement measures at Dworshak has the potential to improve water quality when project discharges exceed current turbine capacity. Options may include increasing the number of turbine units at the powerhouse.

Action 140: The Corps shall design the spillway Number 1 (end bay) deflector at John Day Dam, and implement as warranted, in coordination with the annual planning process.

Absence of a spillway deflector at spill bay Number 1 results in fixed monitor station TDG readings that are unrepresentative relative to the entire spillway tailrace.

Water Temperature Measures. The Action Agencies, in coordination with EPA, NMFS, and USFWS, intend to abate or offset temperature effects associated with FCRPS operations and assess the feasibility of reducing temperature in ways beneficial to fish, based on the actions identified below.

Summer operations for temperature control in the Snake River are included in Section 9.6.1.2.3 under Dworshak Dam operations.

Modifications to make Dworshak NFH water supply rearing operations independent of Dworshak Reservoir temperature control releases in the summer are included in Section 9.6.1.2.6 under Measures to Evaluate and Adjust the Amount of Water Available to Support Flow Objectives.

Evaluations of fish ladder water temperature and adult passage data are included in the adult passage studies discussion in Section 9.6.1.6.2.

Action 141: The Action Agencies shall evaluate juvenile fish condition due to disease in relation to high temperature impacts during critical migration periods. This evaluation should include monitoring summer migrants at lower Columbia and lower Snake river dams to clarify the possible link between temperature and fish disease and mortality. This information will be used to assess the long-term impacts of water temperature on juvenile fish survival.

High water temperatures have been linked to stress and disease in fish. It is essential to acquire a better base of information to understand the sources of fish disease and mortality at the lower Columbia and lower Snake river dams during critical fish migration periods and high temperature events. This information could be used to better understand the effect of high water temperature on juvenile fish survival.

Action 142: The Corps shall work through the regional forum process to identify and implement measures to address juvenile fish mortality associated with high summer temperatures at McNary Dam. As a starting point, the Corps shall

assemble and analyze the temperature data that have been recorded in the McNary forebay, collection channel, and juvenile facilities. The Corps shall examine relationships among juvenile mortality, temperatures, river flow rates, and unit operations in detail. The Corps shall investigate the feasibility of developing a hydrothermal computational fluid dynamics model of the McNary forebay to evaluate the potential to determine optimal powerhouse operations or structural modifications for minimizing thermal stress of juvenile salmon collected in the summer and to conduct a modeling program, if warranted.

Thermal profile data have been routinely collected at McNary Dam for more than a decade. These data formed the basis for special project operations, such as north powerhouse loading operations during the summer-warm-water temperature period. The 1995 NMFS Biological Opinion required the Action Agencies to take measures to reduce the potential for reoccurrence of the 1994 thermal-related mortality observed at McNary Dam. Coutant (1999) suggested that the cause of the observed acute mortalities was a cumulative thermal dose of exposure to high-temperature water received over several days (NMFS 2000c).

Action 143: By June 30, 2001, the Action Agencies shall develop and coordinate with NMFS and EPA on a plan to model the water temperature effects of alternative Snake River operations. The modeling plan shall include a temperature data collection strategy developed in consultation with EPA, NMFS, and state and Tribal water quality agencies. The data collection strategy shall be sufficient to develop and operate the model and to document the effects of project operations.

The modeling plan should focus on water temperatures in the Snake River from Hells Canyon Dam and from Dworshak Dam on the North Fork of the Clearwater River to Bonneville Dam on the Columbia River. Predictive nodes should be located at the near-dam forebays and tailraces of each project. Both one- and multi-dimensional models (due to reservoir stratification) may be needed to fully define expected temperature conditions within the reach. The models should be developed to function both as a pre-season planning tool and to provide predicted outcomes of immediate operations in real time to assist in the in-season water management decision process.

Existing water temperature and meteorological data may be inadequate for this purpose. Existing data and statistical tools will be used to identify locations where additional or improved data collection, in terms of precision, accuracy and frequency, would be most beneficial.

9.6.1.8 Strategy to Improve Fish Facility Operations and Maintenance

The strategy to improve fish facility operations and maintenance addresses the need for adequate O&M budget and funding commitments by the Corps and BPA, coupled with the resource capability to undertake and implement needed O&M actions. The overall goal is to ensure that new and existing fish passage facilities perform at their designed level to increase both juvenile and adult fish survival. An improved O&M program should accomplish the following:

- Meet the increasing O&M needs of aging fish passage and spillway facilities.
- Incorporate new O&M requirements as new fish passage facilities are installed.
- Accommodate expanding annual budget requirements associated with operational changes and research needs.
- Implement preventive maintenance programs for fish passage facilities to assure long-term reliability.

9.6.1.8.1 Fish Passage Plan Development and Implementation. The Corps should continue to annually update the fish passage plan in coordination with NMFS and through the process established by FPOM. Comments developed by NMFS on the draft fish passage plan shall be reconciled by the Corps in writing to NMFS' satisfaction or implemented before release of the final fish passage plan. The Corps should continue to provide weekly and annual reports regarding implementation of the fish passage plan to NMFS.

All planned special facility operation activities that cause any facility to be out of compliance with the operations and criteria described in the main text of the fish passage plan (and expected to result in the take of listed salmon stocks) must be adequately coordinated with NMFS at least 1 month before the anticipated action date. Identifying special project operations in the fish passage plan does not mean that the action has undergone the requirements of an ESA Section 7 consultation. The effects of special operations on listed fish are usually not adequately specified in the fish passage plan, and NMFS requires further essential information, including a brief summary of the action, location, anticipated date and time, analysis of potential effect on listed salmon stocks, and potential alternative actions.

The Corps should work through the FPOM to identify needs and priorities in making hourly individual turbine unit and spill bay operation data available on its Web site, real time, during the juvenile migration season. NMFS needs these data to monitor compliance with operating criteria in the annual fish passage plan (e.g., unit operating priorities and spill patterns), as well as for agreed-upon special project operations for research or maintenance.

9.6.1.8.2 Actions to Improve Operation and Maintenance of Passage Facilities

Action 144: The Corps, in coordination with the Regional Forum, shall maintain juvenile and adult fish facilities within identified criteria and operate FCRPS projects within operational guidelines contained in the Corps' Fish Passage Plan. The Corps shall coordinate with NMFS on the development of these criteria and operational guidelines before the start of each fish passage season (generally February 1).

Insufficient ladder entrance water depth and insufficient entrance attraction velocity are factors that negatively affect adult fish passage (Bell 1991). Maintaining fishways within optimum

criteria for passage is likely to reduce dam passage delays for migrating salmon. Monitoring adult fishways frequently and improving the maintenance and repair of fishway components such as pumps, gear boxes, diffuser valves, and entrance gate controls are expected to improve system operational reliability.

The following are examples of Fish Passage Plan issues that have to be resolved before the 2001 fish passage season:

- The frequency of daily inspections for all fish passage facilities throughout the passage season
- A schedule for completion of identified maintenance needs and repairs
- A cleaning schedule and frequency table of juvenile bypass collection channel orifices in operating units during the high debris months (April through June)
- A schedule for closing floating orifices (which are to be closed before the main entrances) in adult fishways during emergency auxiliary water supply outages

Upgrading existing adult fish passage facilities will also aid the monitoring effort and contribute to maintenance of optimum criteria. The upgrade should include the following:

- Automation of control systems
- Placement of staff gauges (for determining water elevations) in areas that are accessible for both cleaning and reading
- Providing velocity meters in areas of known low velocity in the collection channels

Action 145: The Corps shall develop and implement preventative maintenance programs for fish passage facilities that ensure long-term reliability, thereby minimizing repair costs.

Action 146: The Corps shall address debris-handling needs and continue to assess more efficient and effective debris-handling techniques to ensure that the performance of both new and old fish passage facilities will not be compromised.

This effort should include the investigation of debris shear booms at all FCRPS Corps projects that pass listed fish. Design and construction of appropriate facilities should be undertaken as warranted. Shear booms keep as much debris as possible from accumulating at the upstream powerhouse face, where the debris increases fish injury and mortality and requires more labor-intensive handling and removal. These investigations will include assessment of predator cover

and potential guidance of juvenile salmonids away from fish passage facilities as a result of the boom structure.

9.6.1.9 Advance Planning for Possible Additional Actions

Action 147: As a contingency plan, the Corps (in cooperation with other Federal agencies) shall develop a project management plan to reevaluate more intensive hydropower-related actions (including breaching) for the four lower Snake River dams. The project management plan will identify the scope, schedule, costs, tasks, products, and responsibilities for the reevaluation study. The study should assess all significant changed conditions to the Lower Snake River Feasibility Report and Environmental Impact Statement (Corps 1999c). The project management plan should be consistent with direction from Congress, Corps authorities, and other legal requirements. The completed project management plan should be coordinated with the appropriate regional interests. The project management plan should include, but not be limited to, plans to mitigate disproportionate impacts to communities, industries, and Tribes, detailed water and air quality effects, implementation plans, and a complete public involvement program. The decision to start the reevaluation study should result from the NMFS check-in process in Section 9.5. The Corps will request funding or reprogramming to complete the project management plan within 1 year after NMFS' issuance of a check-in report indicating the need to seek additional authority. The study should result in a general reevaluation report and supplemental environmental impact statement, which would be used to seek authorization and/or appropriations to implement, recommended action(s), if needed. The general reevaluation report/ supplemental environmental impact statement will require approximately 2 years to complete.

Action 148: The Corps shall conduct detailed engineering and design work for improvements recommended in the general reevaluation report and supplemental environmental impact statement described in the preceding action. The Corps shall seek funding to allow initiation of the engineering and design work to occur immediately upon completion of the final general reevaluation report. The engineering and design work shall include only those activities on (or near) the implementation schedule critical path for the recommended actions, up to the award of the first construction contract. For a dam breach recommendation, the critical path activities shall include turbine physical modeling (for use as low level outlets), rock source explorations for embankment erosion protection (riprap), and hydraulic (physical) modeling for the embankment removal and channelization. Tentative milestones for the general reevaluation report/EIS and engineering and design work are as follows, based on the check-in process identified in Section 9.5:

- | | |
|--------|---|
| Year 1 | - Complete project management plan |
| | - Project management plan regional coordination |
| Year 2 | - Initiate general reevaluation report/supplemental environmental impact statement |
| Year 3 | - Complete final general reevaluation report/supplemental environmental impact statement |
| | - Initiate detailed engineering and design |
| | - Issue approval of general reevaluation report/supplemental environmental impact statement |
| | - Seek authorization and appropriations |

Although breaching is not essential to implementation of the initial actions called for in the RPA, which constitute a non-breach approach, the RPA requires that the Action Agencies prepare for the possibility that breaching or other hydropower actions could become necessary. These actions will reduce the time needed to seek congressional authorization, if necessary, and thus reduce the time needed for possible implementation.

It is unacceptable to recommend a non-breaching alternative in the Lower Snake River feasibility report/environmental impact statement with a future contingency for breaching. Future decisions (whether they are made in 5 or 10 years) must be made with the best available information on the effects on all resources and users. Therefore, future decisions will require some reevaluation and NEPA compliance. In addition, any reevaluation of breaching must also consider all possible alternative actions as well.

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9.6.2 Habitat Actions

The habitat strategy is intended to accelerate efforts to improve survival in priority areas in the short term, while laying a foundation for long-term strategies through subbasin and watershed assessment and planning.

In the short term, Federal agencies commit in the Basinwide Recovery Strategy to focus immediate attention on priority subbasins, i.e., those with potential for significant improvement in anadromous fish productive capacity as a result of habitat restoration. The Basinwide Recovery Strategy identifies these short-term actions, timelines, and responsible Federal agencies. This biological opinion identifies the Action Agencies' contribution to the Basinwide Recovery Strategy. Where costs are stated in this biological opinion, they are estimates meant to help define the scale and pace of the action, not specific amounts the Action Agencies must actually spend to comply.

Over the long term, the habitat strategy has three overarching objectives: 1) protect existing high quality habitat, 2) restore degraded habitats on a priority basis and connect them to other functioning habitats, and 3) prevent further degradation of tributary and estuary habitats and water quality.

9.6.2.1 Actions Related to Tributary Habitat

When related to the basic habitat needs of listed anadromous fish, tributary habitat efforts have the following objectives:

- Water quantity—increase tributary water flow to improve fish spawning, rearing, and migration.
- Water quality—comply with water quality standards, first in spawning and rearing areas, then in migratory corridors.
- Passage and diversion improvements—address in-stream obstructions and diversions that interfere with or harm listed species.
- Watershed health—manage both riparian and upland habitat, consistent with the needs of the species.
- Mainstem habitat—improve mainstem habitat on an experimental basis and evaluate the results.
- Estuary improvement—improve and restore habitat conditions in the Columbia River estuary.

Action 149: BOR shall initiate programs in three priority subbasins (identified in the Basinwide Recovery Strategy) per year over 5 years, in coordination with NMFS, FWS, the states and others, to address all flow, passage, and screening problems in each subbasin over 10 years. The Corps shall implement demonstration projects to improve habitat in subbasins where water-diversion-related problems

could cause take of listed species. Under the NWPPC program, BPA addresses passage, screening, and flow problems, where they are not the responsibility of others. BPA expects to expand on these measures in coordination with the NWPPC process to complement BOR actions described in the action above.

The Federal agencies have identified priority subbasins where addressing flow, passage, and screening problems could produce short-term benefits. This action initiates immediate work in three such subbasins per year, beginning in the first year with the Lemhi, Upper John Day, and Methow subbasins. Subbasins to be addressed in subsequent years will be determined in the annual and 5-year implementation plans. NMFS will consider the level of risk to individual ESUs and spawning aggregations in the establishment of priorities for subsequent years. At the end of 5 years, work will be underway in at least 15 subbasins. The objective of this action is to restore flows needed to avoid jeopardy to listed species, screen all diversions, and resolve all passage obstructions within 10 years of initiating work in each subbasin. BOR is the lead agency for these initiatives and will facilitate their implementation. In addition, recognizing the critical importance of starting this work quickly, BPA will expand on measures under the NWPPC program to complement BOR's action. To support this work, NMFS will supply BOR with passage and screening criteria and one or more methodologies for determining instream flows that will satisfy ESA requirements. The Corps will use available funding and authorities to implement restoration actions in priority subbasins and in areas such as the Walla Walla basin, where water-diversion-related issues could cause take of listed species.

Action 150: In subbasins with listed salmon and steelhead, BPA shall fund protection of currently productive non-Federal habitat, especially if at risk of being degraded, in accordance with criteria and priorities BPA and NMFS will develop by June 1, 2001.

This opinion puts high priority on protecting habitat that is currently productive, especially if it represents a habitat type that already limits an ESU's productivity (e.g., summer rearing or over-wintering habitat). BPA should protect these habitats through conservation easements, acquisitions, or other means, working with non-profit land conservation organizations and others.

Action 151: BPA shall, in coordination with NMFS, experiment with innovative ways to increase tributary flows by, for example, establishing a water brokerage. BPA will begin these experiments as soon as possible and submit a report evaluating their efficacy at the end of 5 years.

Tributary flow problems are widespread. It is unclear whether and how solutions can be implemented through existing laws and administrative processes. To test new approaches to this problem, Bonneville will conduct experiments such as organizing a non-profit water brokerage to demonstrate transactional strategies for securing tributary flow—and, where feasible, addressing water quality—in streams with significant non-Federal diversions. The project would develop a

competitive process to supply water to increase flows and water quality at the lowest cost. Expectations for this project are as follows:

- In year 1, BPA will fund development of a methodology acceptable to NMFS for ascertaining instream flows that meet ESA requirements, establish a new non-profit entity or contract with a non-profit entity(ies) to carry out this project, require the non-profit entity(ies) to develop an operations plan, and initiate a trial round of water solicitations.
- In years 2 through 5, the non-profit entity should be fully operational, processing water solicitations and completing transactions according to the operations plan, and should explore possibilities for accomplishing water and other habitat objectives together.

An objective third-party evaluator will review the program after 5 years, and a decision will be made whether to continue it. The estimated BPA expenditure for this project is \$2.5 million in the first year, \$5 million in the second year, and \$5 to \$10 million per year thereafter, as justified by prospective transactions. NMFS and BPA should make joint decisions regarding funding beyond the \$5 million-per-year base in years 2 to 5, in cooperation with the NWPPC's prioritization process. Recognizing recent amendments to the Columbia River Basin Fish and Wildlife Program regarding a land and water trust fund, BPA and NMFS will explore the possibility of integrating this action item with such a trust fund.

Action 152: The Action Agencies shall coordinate their efforts and support offsite habitat enhancement measures undertaken by other Federal agencies, states, Tribes, and local governments by the following:

- Supporting development of state or Tribal 303(d) lists and TMDLs by sharing water quality and biological monitoring information, project reports and data from existing programs, and subbasin or watershed assessment products.
- Participating, as appropriate, in TMDL coordination or consultation meetings or work groups.
- Using or building on existing data management structures, so all agencies will share water quality and habitat, data, databases, data management, and quality assurance.
- Participating in the NWPPC's Provincial Review meetings and Subbasin Assessment and Planning efforts, including work groups.
- Sharing technical expertise and training with Federal, state, Tribal, regional, and local entities (such as watershed councils or private landowners).
- Leveraging funding resources through cooperative projects, agreements and policy development (e.g., cooperation on a whole-river temperature or water quality monitoring or modeling project).

This effort would include funding implementation measures recommended in EPA- and state-approved tributary TMDLs that NMFS determines are essential to avoid jeopardy to the listed stocks.

Measures implemented by the Action Agencies to improve habitat can complement efforts by other Federal agencies, states, Tribes, and regional or local entities such as watershed councils. Similarly, endeavors by other Federal agencies, states, and Tribes can complement those of the Action Agencies. As an example of the former, information garnered from the studies and other measures implemented consistent with this opinion can be helpful to states and Tribes as they prepare 303(d) lists and TMDLs for tributaries in the Columbia River basin. Information obtained by states and Tribes as they develop TMDLs can be helpful to the Action Agencies as they study ways to improve water quality for fish through subbasin assessment and planning under the NWPPC's amended fish and wildlife program. More specifically, temperature monitoring stations installed by one entity could benefit all. Therefore, when Action Agency measures to improve habitat will complement efforts by states, Tribes, and local governments, and vice versa, the Action Agencies (as part of the subbasin planning process or management or implementation of the NWPPC's fish and wildlife program) shall consult with these entities to discern how their respective water quality efforts can complement each other and avoid duplication. Cost-sharing may be possible. The Action Agencies shall then implement measures as approved through applicable planning processes.

These actions are intended to improve Columbia River basin water quality, with the goal of being consistent with or complementing the NWPPC amended fish and wildlife program, the Clean Water Action Plan, the Unified Federal Policy for a Watershed Approach to Federal Land and Resource Management, the states of Washington and Oregon's Lower Columbia River Estuary Program Comprehensive Conservation and Management Plan, the Inter-Governmental Task Force for Monitoring principles, and state and local watershed planning efforts.

Action 153: BPA shall, working with agricultural incentive programs such as the Conservation Reserve Enhancement Program, negotiate and fund long-term protection for 100 miles of riparian buffers per year in accordance with criteria BPA and NMFS will develop by June 1, 2001.

Under certain farm incentive programs, farmers and ranchers may enter into 10- to 15-year contracts to plant riparian buffers or restore wetlands on streams that provide habitat for listed salmonids. Experience with similar programs suggests that these buffers can be made permanent, or at least long-term, by adding an increment to the contract price. Securing such protection adds value in terms of riparian corridor restoration and, where recognized by state law, instream flow restoration.

Action 154: BPA shall work with the NWPPC to ensure development and updating of subbasin assessments and plans; match state and local funding for coordinated development of watershed assessments and plans; and help fund technical support

for subbasin and watershed plan implementation from 2001 to 2006. Planning for priority subbasins should be completed by the 2003 check-in. The action agencies will work with other Federal agencies to ensure that subbasin and watershed assessments and plans are coordinated across non-Federal and Federal land ownerships and programs.

In the long term, habitat recovery and watershed restoration for non-Federal public, Tribal, and private lands require state and local stewardship. An overall framework for this stewardship can be created through subbasin and watershed plans and related recovery plans which establish goals, objectives, and priority actions that are coordinated across Federal and non-Federal ownerships and programs. BPA is funding the bulk of NWPPC's subbasin assessments and plans. These plans will provide an important context for classifying and prioritizing watersheds for protection and restoration. They will also provide the foundation for ESA recovery planning which will be conducted in a similar time frame. Several watershed scale efforts are underway. The Federal land management agencies are conducting watershed assessments in most watersheds with significant Federal land ownership. State and local governments are conducting assessments and developing plans at the watershed scale to meet ESA regulations, CWA TMDLs, and other needs. In its final 4(d) rule (July 10, 2000), NMFS committed to working with states to develop guidelines for watershed assessments and plans. As these steps are completed, priorities, targets, and schedules will emerge, and priorities can be adjusted. As described in the Basinwide Recovery Strategy, all the Federal agencies are committed to coordinating assessment, planning, and priorities across non-Federal and Federal land ownerships and programs. As subbasin and watershed plans are completed, the Action Agencies should identify habitat actions in annual and 5-year implementation plans and implement them.

Action 155: BPA, working with BOR, the Corps, EPA, and USGS, shall develop a program to 1) identify mainstem habitat sampling reaches, survey conditions, describe cause-and-effect relationships, and identify research needs; 2) develop improvement plans for all mainstem reaches; and 3) initiate improvements in three mainstem reaches. Results shall be reported annually.

Large-scale water development over the last 65 years has inundated and significantly degraded mainstem habitat. Populations such as fall chinook that were once highly productive spawned in the mainstem and in the lower reaches of major tributaries. Studies in other river systems in the Northwest indicate that mainstem habitat improvements can result in greater population and habitat diversity, complexity, and productivity. However, no systematic assessment of habitat modifications from dam construction has been done, nor have potential restoration sites and specific benefits to salmon and steelhead been identified. BPA, working with the Corps, will take immediate steps to begin to address these uncertainties by collecting baseline data, improving mainstem reaches in ways that mimic the range and diversity of historic habitat conditions as much as possible, and monitoring and evaluating the results. Results will be reported annually. After 5 years, NMFS and the Action Agencies, in consultation with NWPPC and others, will determine whether to make changes in this program.

Action 156: The Action Agencies and NMFS shall study the feasibility (including both biological benefits and ecological risks) of habitat modification to improve spawning conditions for chum salmon in the Ives Island area.

The objectives of the study will be to determine whether it would be beneficial to increase the frequency of access to spawning habitat or the areal extent of spawning habitat by means other than flow augmentation. The feasibility study will evaluate actions to alter the hydraulic control points that limit flow in the Ives Island area to provide the same areal extent and quality of sustainable spawning habitat (including characteristics such as upwelling through the gravels currently present at the site) at lower levels of Bonneville discharge; reconstruct spawning channels to increase the extent of habitat available at a given level of Bonneville discharge; and maintain hydraulic connections between tributary habitats and the mainstem Columbia River to allow entry for adults and emergence channels for juveniles.

Action 157: BPA shall fund actions to improve and restore tributary and mainstem habitat for CR chum salmon in the reach between The Dalles Dam and the mouth of the Columbia River.

The purpose of this action is to compensate for effects of FCRPS water management in the Ives Island area, which appreciably diminish the value of critical spawning habitat for the survival and recovery of CR chum salmon. The FCRPS has been a relatively important factor for decline of this ESU. Bonneville and The Dalles dams limit access to potential spawning habitat further upstream and Bonneville Reservoir drowned known historical habitat in Bonneville pool. Spawning is currently known in only two areas: the Grays River system in the Columbia River estuary and the Hardy/Hamilton creeks/Ives Island complex, downstream of Bonneville Dam.

Although most of the existing subbasin populations and the ESU as a whole are on a slightly positive growth trajectory (ESU-level $\lambda = 1.035$), RPA water management operations will continue to limit the areal extent of spawning habitat in Bonneville pool and the Ives Island complex in most water years. Therefore, BPA will 1) fund surveys of existing and potential tributary and mainstem habitat in the Columbia River between The Dalles Dam and the mouth of the Columbia River for suitable protection and restoration projects, 2) develop and implement an effective habitat improvement plan, 3) protect, via purchase, easement, or other means, existing or potential spawning habitat in this reach and adjacent tributaries (i.e., protect, restore, and/or create potentially productive spawning areas). The overall goal of this effort will be to ensure the survival and recovery of CR chum salmon by ensuring the availability of diverse, productive spawning habitats over a wide range of water years.

9.6.2.2 Actions Related to Estuarine Habitat

Estuarine protection and restoration must play vital roles in rebuilding the productivity of listed salmon and steelhead throughout the Columbia River basin. The states of Oregon and Washington, with congressional authorization under the CWA, have developed a Comprehensive

Conservation and Management Plan through the Lower Columbia River Estuary Program (LCREP). The Federal agencies strongly support the actions of this plan that contribute to salmon recovery and seek to expand on them.

The following action items call on the Action Agencies, primarily the Corps and BPA, to play an important role in estuary restoration efforts. The Corps is meant to play a lead role, with BPA primarily providing cost-share funding. The Corps and BPA actions are not meant to hinge on LCREP approval, but they are meant to be fully coordinated with the LCREP.

Action 158: During 2001, the Corps and BPA shall seek funding and develop an action plan to rapidly inventory estuarine habitat, model physical and biological features of the historical lower river and estuary, identify limiting biological and physical factors in the estuary, identify impacts of the FCRPS system on habitat and listed salmon in the estuary relative to other factors, and develop criteria for estuarine habitat restoration.

A good deal is unknown about the ecology of the Columbia River estuary insofar as it affects listed species. It is important to develop a better understanding of historic salmon rearing patterns in the estuary; historic changes in the distribution, amounts, and classes of estuarine and floodplain habitat available to juvenile salmonids; variability in salinity, temperature, water depth, velocity, dissolved oxygen, and turbidity; habitat-salmon associations; sedimentation rates; salmon and habitat conditions in the transition zone; long-term variability and trends in the size, timing, and abundance of hatchery and wild outmigrants from the Columbia River; and the relative effects of inflow from upriver, changes in bathymetry due to the navigation channel, and changes in habitat due to other forms of development. Under this action item, the Corps and BPA are expected to develop programs to build an understanding of these matters and, in the relatively short term, to develop criteria for estuary habitat restoration on the basis of the best available information.

Action 159: BPA and the Corps, working with LCREP and NMFS, shall develop a plan addressing the habitat needs of salmon and steelhead in the estuary.

BPA and the Corps, working with LCREP and NMFS, will develop specific plans for salmon and steelhead habitat protection and enhancement. These plans should contain clear goals for listed salmon conservation in the estuary, identify habitats with the characteristics and diversity to support salmon productivity, identify potential performance measures, identify flow requirements to support estuarine habitat requirements for salmon, and develop a program of research, monitoring, and evaluation. The plans should be completed by 2003.

Action 160: The Corps and BPA, working with LCREP, shall develop and implement an estuary restoration program with a goal of protecting and enhancing 10,000 acres of tidal wetlands and other key habitats over 10 years, beginning in 2001, to rebuild productivity for listed populations in the lower 46 river miles of the

Columbia River. The Corps shall seek funds for the Federal share of the program, and BPA shall provide funding for the non-Federal share. The Action Agencies shall provide planning and engineering expertise to implement the non-Federal share of on-the-ground habitat improvement efforts identified in LCREP, Action 2.

Much of the complexity of the estuary's historic shallow-water habitat and much of the estuary's saltwater wetlands have been lost due to the effects of local, navigational, and hydropower development. LCREP proposes a 10-year program to protect and enhance high-quality habitat on both sides of the river to support salmon rebuilding. A high priority should be put on tidal wetlands and other key habitats to rebuild productivity in the lower 46 river miles. Federal agencies will provide technical and financial support for this program and for efforts to implement on-the-ground activities identified in planning.

As more information is gained from inventory and analytical work, the 10,000-acre goal may be modified to ensure that habitats that are determined to be important to the survival and recovery of anadromous fish are addressed. Examples of acceptable estuary habitat improvement work include the following:

- Acquiring rights to diked lands
- Breaching levees
- Improving wetlands and aquatic plant communities
- Enhancing moist soil and wooded wetland via better management of river flows
- Reestablishing flow patterns that have been altered by causeways
- Supplementing the nutrient base by importing nutrient-rich sediments and large woody debris into the estuary
- Modifying abundance and distribution of predators by altering their habitat
- Creating wetland habitats in sand flats between the north and south channels
- Creating shallow channels in inter-tidal areas
- Enhancing connections between lakes, sloughs, side channels, and the main channel

The Corps and BPA will put high priority on improving access to and the quality of chum habitat, especially in the Grays River. The work outlined in this action is in addition to any mitigation/restoration work that may be connected to the Corps' channel-deepening project.

- Action 161:** Between 2001 and 2010, the Corps and BPA shall fund a monitoring and research program acceptable to NMFS and closely coordinated with the LCREP monitoring and research efforts (Management Plan Action 28) to address the estuary objectives of this biological opinion.
- Action 162:** During 2000, BPA, working with NMFS, shall continue to develop a conceptual model of the relationship between estuarine conditions and salmon population structure and resilience. The model will highlight the relationship among hydropower, water management, estuarine conditions, and fish response. The work will enable the agencies to identify information gaps that have to be addressed to develop recommendations for FCRPS management and operations.
- Action 163:** The Action Agencies and NMFS, in conjunction with the Habitat Coordination Team, will develop a compliance monitoring program for inclusion in the first 1- and 5-year plans.

Compliance monitoring is necessary to determine how well management actions are implemented. From a regulatory perspective, compliance monitoring is necessary to ensure that agencies and individuals responsible for mitigation or restoration activities complete their responsibilities. From a biological perspective, NMFS must know how well a management action is implemented. If salmon do not respond, NMFS will be able to distinguish between management that did not work and management that was not implemented.

Some compliance monitoring will be conducted during the monitoring and evaluation program outlined in Section 9.6.5. However, not all sites will be checked at the appropriate intervals during this program. Therefore, the agency or party conducting each action will be responsible for keeping a log book of implementation, which is entered monthly into a web-based data archive. NMFS will randomly send out field staff to check on the log books and validate their entries.

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9.6.3 Harvest Measures

9.6.3.1 Overview

Fisheries that affect listed fish originating in the Columbia River basin, whether in the tributaries, the mainstem, or the ocean, have been and continue to be subject to biological opinions addressing harvest. In all cases, fisheries must be operated to avoid jeopardizing listed species. This opinion addresses the operation and management of FCRPS, not harvest. Harvest management is not within the authorities of the Action Agencies; therefore, additional constraints cannot be imposed on fisheries by this biological opinion. Instead, this section outlines harvest measures the Action Agencies can facilitate to meet offsite mitigation goals for hydrosystem impacts and measures that may further reduce the take of listed species. The Action Agencies can contribute to the development and deployment of selective fisheries potentially reducing impacts on listed fish and allowing increases in harvest without raising impacts on listed fish. This section outlines changes in the fishery management system that are critical to the successful deployment of selective fishery measures and harvest reforms that will increase the certainty and efficacy of new and existing harvest management regimes, thereby raising the margin of safety afforded to listed fish.

Fisheries in the Columbia River basin have been significantly reduced in recent years in response to a number of factors that include a general decline in abundance, an increasing scientific and policy awareness of the importance of managing fisheries for natural stocks and stock groups, improved management capabilities, and the requirement to reduce impacts on listed species. Many reviewers of the draft biological opinion correctly pointed out that harvest managers have been implementing harvest reforms for many years. Weak stock management, abundance-based management, harvest rate and escapement goal management, and other kinds of major advancements (i.e., reforms) have been used for some time and continue to evolve and improve. Some reviewers believe that harvest managers have been responding to the declining status of natural fish caused largely by non-fishing factors, at great cost to their fisheries, economies, and cultures. They also point out that further reductions in harvest may benefit some species, such as Snake River fall chinook or Snake River steelhead, but that such additional reductions, even if achieved, will not help recover listed species.

The decline in the status and abundance of natural populations has many causes, including, but not limited to, the development and operation of FCRPS. It will take a long time for recovery efforts to show positive results. Thus, harvest constraints now in place must continue for some time so as not to thwart other recovery efforts. New and/or expanded harvest reforms, such as those that increase the selectivity of fisheries either by avoiding contact with listed fish or by reducing the mortality rate of listed fish released from fisheries, offer the potential to reduce impacts on some listed ESUs. It may be possible to realize this potential without net reductions in harvest and to increase total harvest without increasing impacts on listed ESUs. If successfully implemented, such reforms would provide easily quantified survival benefits for listed fish. The reforms provide potential opportunities for the Action Agencies to meet offsite

mitigation goals. To the extent that the reforms are facilitated by the Action Agencies, it should be possible to allocate these benefits.

For most of the listed ESUs, opportunities to improve survival through additional harvest reductions are limited because they are not affected, or are affected only minimally, by today's much-reduced fisheries. Impacts on those ESUs that still are affected by harvest occur in fisheries targeting healthy and abundant stocks, particularly hatchery stocks. Even for the ESUs affected by these incidental harvests, impacts already have been greatly reduced in recent years in response to declining abundance of nonlisted as well as listed species. As a result, even the complete elimination of all remaining fisheries would yield only limited benefits for many of the ESUs.

Some who commented on the draft opinion advocated further reductions in harvest, in some cases its complete elimination. They argued that reducing harvest is more cost-effective than other recovery measures, that it provides more certain benefits to listed fish, and that it more closely matches the intent of ESA because it prohibits the killing of listed species. Others disagreed, pointing out that extreme harvest reductions have already occurred, that the harvest sector has already paid more than its fair share, that additional harvest constraints can do little to change the basic productivity of natural stocks, and that current harvest constraints fail to meet Tribal obligations. NMFS acknowledges the validity in each of these views, but respectfully disagrees that they make a compelling case to implement any of the more extreme alternatives. The solution to the recovery problem cannot be found in the complete elimination of harvest, in sacrificing what little remains of an entire sector, or in further exacerbating an already extreme burden on the Tribes, as a prerequisite to changes in other sectors. Nor can it be found in allowing increases in harvest simply because harvest constraints have been "proven" not to recover listed species, or because reasoned arguments exist as to why the current allocation of the conservation burden is unfair.

NMFS' overall approach to recovery, and the reasoning that supports it, is described in greater detail in the Basinwide Recovery Strategy, which provides the broader context for this biological opinion. For harvest, the approach described in the Basinwide Recovery Strategy is to constrain ocean and inriver harvests at or below recently established rates to allow time for other recovery measures to take effect. As noted above, this opinion cannot mandate and, therefore, does not presume that additional reductions in harvest relative to those described in the Basinwide Recovery Strategy will occur. However, maintaining harvest constraints is critical to the success of recovery efforts. In a few cases, additional harvest reductions would substantially increase the prospects, and may actually be necessary, for recovery. The scientific risk assessments that inform this biological opinion assume that, at the very least, recently established harvest constraints and their associated survival benefits will be maintained. It is, therefore, both reasonable and prudent for the Action Agencies to contribute to measures to ensure that these constraints continue, to increase the certainty and efficacy of harvest management measures and, thereby, the margin of safety afforded listed fish, and to enable additional reductions through improved fishery selectivity. This is particularly true for the immediate future, since harvest

measures yield immediate benefits while other measures to increase survival of listed fish require more time to produce benefits.

This RPA does not assume that the Action Agencies will provide all of the funding necessary to implement the harvest actions described here, as some are clearly the responsibility of those with harvest management authority. As stated previously in this biological opinion, where offsite mitigation actions imposed on the Action Agencies by this RPA overlap with the responsibilities of other Federal and non-Federal entities, an appropriate sharing of costs and implementation responsibilities must be worked out.

9.6.3.2 Measures to Reform Harvest

This RPA defines harvest reform broadly; it includes implementing various kinds of harvest management reforms such as selective fishery management strategies (e.g., mark-selective fisheries), developing and applying alternative fishing methods and gear types, and creating or expanding fishing opportunities in areas or at times when listed fish are not present. As noted previously, many harvest reforms have already been implemented by the fishery managers. Realizing the full potential of harvest reforms, however, requires development and implementation of new and more broadly applied selective fishing techniques, as well as augmenting and/or modifying existing programs and tools for managing fisheries, including systems for monitoring and evaluating stock and fishery-specific impacts. Because most or all hatchery fish will have to be marked to improve information on the status of natural populations and/or to enable mark-selective fisheries, existing catch sampling and stock identification programs and methodologies will have to be modified and significantly augmented, both inside and outside of the basin. Existing management and assessment tools, including various models, analytical methods, procedures, and associated databases, will also have to be refined and/or replaced.

The Basinwide Recovery Strategy particularly emphasizes the development, implementation, and expansion of mark-selective fisheries. Mark-selective fisheries are not recovery tools, but rather means to allow fishing to continue. Used primarily in certain recreational fisheries, mark-selective fisheries also may provide significant economic benefits to commercial fisheries that use live-capture selective fishing techniques. Live-caught fish can be delivered to buyers in better condition, potentially enhancing their market value. Thus, mark-selective and other forms of selective fishing may contribute to meeting multiple objectives, including FCRPS mitigation mandates, FCRPS offsite mitigation responsibilities, and Tribal and non-Tribal fishery obligations.

Realizing the full potential of selective fishing depends on a number of elements, both technical and policy-level. Before the strategy would work in Tribal fisheries, social, economic, and cultural impacts would have to be addressed in ways the Tribes support. The fishers must fish in times or places where encounters with listed fish are minimal, or they must use gear and methods that allow fish to be caught alive, so that those needing protection can be released with a minimal

amount of handling loss. In selective fisheries based on live-catch strategies, it must be possible and practical for the fishers to visually sort between fish that are harvestable and those that are not. Sorting between different species—sockeye versus chinook, for example—is fairly straightforward and promising for certain fisheries in the Columbia River basin, including some that would sort between healthy natural stocks and listed stocks. However, selectivity directed towards the harvest of hatchery fish in mixed stock fishing areas, including the mainstem, will rely on mass marking of hatchery-produced fish. Fortunately, it is now feasible to mass-mark hatchery fish using new, relatively economical technologies, but those technologies must be widely used to make mark-selective fisheries feasible in mixed stock areas. Sufficiently precise and accurate methods must exist to estimate incidental mortalities on fish that are captured and released. Methods for maintaining critical management systems must be developed and deployed so that managers can maintain and enhance their ability to monitor and evaluate the effects of fisheries and the status of stocks.

Some selective fishing strategies are designed to avoid catching listed species in the first place. These can reduce the catch of listed species in fisheries targeting strong runs. An example of this strategy is the gill net exchange program recently developed by the Action Agencies, Tribes, and Federal agencies. This program, partially implemented in the autumn 2000 mainstem Tribal fishery, should be assessed for economic, legal, and social implications and, if appropriate and agreed to by the Tribes, expanded in the future. Canadian fishers and managers are engaged in an ongoing, multiyear program to develop and assess innovative techniques to minimize the catch of weak natural runs. One such technique involves using “weed lines” on gill nets in the Skeena River to reduce impacts on depressed steelhead runs in the commercial salmon fishery. These and other avoidance techniques should be investigated for application in Columbia River basin fisheries.

9.6.3.2.1 Measures to Develop or Expand Use of Selective Fishing Methods and Gear

Action 164: The Action Agencies shall work with NMFS, USFWS, and Tribal and state fishery management agencies in a multiyear program to develop, test, and deploy selective fishing methods and gear that enable fisheries to target nonlisted fish while holding incidental impacts on listed fish within NMFS-defined limits. The design of this program and initial implementation (i.e., at least the testing of new gear types and methods) shall begin in FY 2001. Studies and/or pilot projects shall be under way and/or methods deployed by the 3-year check-in.

The purpose of this action is to enable the development and deployment of selective fishing gear and methods so some level of fishing can continue even when listed fish are present. Because it will take time to develop, test, refine, and deploy different types of methods and gear in various conditions, this action necessarily will involve a continuing, multiyear program.

The effectiveness of new selective fishing gear and methods depends to a large degree on whether they are accepted by the fishers. The program to develop and test selective fishery

options should engage members of the fishing community, drawing on their proven abilities to find innovative and practical solutions to fishing-related problems. Funding should be made available and proposals solicited from agencies, Tribes, industry, and the public to develop and test selective fishing methods and/or gear using carefully designed and monitored applied experiments. Live-capture fishing gear and methods such as traps, seines, tangle nets, and revival tanks should be explored. The program should be implemented as soon as possible, building on the experiences of the Canadians, states, and Tribes. Strategies that work should be deployed as broadly and quickly as possible. The program also should include exploration of methods and strategies to reduce incidental fishing mortalities in fisheries, regardless of whether they use conventional or live-capture gear types.

9.6.3.2.2 Measures to Address Effects of Selective Fishing on Fishery Management Systems (e.g., Fishery Management and Stock Assessment Models)

Action 165: The Action Agencies shall work with NMFS, USFWS, Tribal and state fishery managers, and the relevant Pacific Salmon Commission and Pacific Fishery Management Council (PFMC) technical committees to develop and implement methods and analytical procedures (including revising and/or replacing current fishery management and stock assessment models based on these methods and procedures) to estimate fishery and stock-specific management parameters (e.g., harvest rates). The Action Agencies shall place particular emphasis on current methods and procedures affected by the transition to mass marking of Columbia River basin hatchery produced fish and/or deployment of selective fishery regimes in the Columbia River basin, addressing these concerns within a time frame necessary to make the new selective fishing regimes feasible. Specifically, the Action Agencies shall facilitate the development of models, methods, and analytical procedures by the 3-year check-in.

Current harvest management strategies and stock assessment tools, especially including the models used to implement and monitor them, evolved in the context of non-selective fisheries. These models have long played a crucial role in the management of ocean and freshwater fisheries and in stock assessment programs. Most of them are based on data acquired over the last two decades from the coastwide CWT program. The models include the coastwide chinook model the United States and Canada used to implement and monitor the chinook regime contained in the Pacific Salmon Treaty and similar models developed and used by the PFMC and the *U.S. v. Oregon* Technical Advisory Committee. These modeling tools were not designed to accommodate selective fisheries; they evolved in the context of non-selective fisheries, using the basic assumption that the catch in a fishery represents a random removal of fish from the fishery population. With the advent of mass marking and selective fishing, this key assumption is no longer valid. Because it is more critical than ever to sustain and enhance the stock and fishery-specific information and analyses that these tools provide, the models and associated analytical techniques must be substantially revised or replaced. This will be a significant but necessary undertaking. Besides maintaining and enhancing critical fishery management and stock

assessment capabilities, this action will help ensure compliance with the Pacific Salmon Treaty and other agreements.

Fishery management models and related management systems in the various areas and fisheries are interdependent. Changes in ocean fisheries management and strategies affect river fisheries and vice-versa. Clearly, this action item involves matters that overlap with the responsibilities of the fishery managers. As stated previously, an appropriate sharing of costs and implementation responsibilities must be worked out among the relevant parties.

Action 166: The Action Agencies shall work with NMFS, USFWS, the Pacific States Marine Fisheries Commission, and Tribal and state fishery management agencies to implement and/or enable changes in catch sampling programs and data recovery systems, including any required changes in current databases (e.g., reformatting) and associated data retrieval systems, pursuant to the time frame necessary to implement and monitor mass marking programs and/or selective fishery regimes in the Columbia River basin. Specifically, the Action Agencies shall facilitate the revision of programs and systems, as needed, by the 3-year check-in.

Changes in fishery monitoring and data systems will be necessary to provide the degree of resolution required to monitor the status of listed populations while enabling some continued fishing. For years, the adipose fin clip was used solely to identify fish that carry a CWT. Now, fish with an adipose clip may or may not carry a CWT, and a fish that has a CWT may or may not have a fin clip. For this reason, significant changes must be made in sampling and monitoring programs. Most notably, electronic tag detectors will be needed to detect and recover CWTs from a broad range of fisheries, natural spawning areas, and hatchery escapements to maintain critical stock-specific and fishery-specific information provided by the CWT system. Fishery management databases, including the coastwide databases maintained by the Pacific States Marine Fisheries Commission on behalf of the states, Tribes, the United States Federal government, and Canada, will have to be modified and reformatted and new protocols adopted to accommodate changes in data types, collection methods, access methods, and use.

Action 167: The Action Agencies shall work with NMFS, USFWS, and Tribal and state fishery management agencies to develop improved methods for estimating incidental mortalities in fisheries, with particular emphasis on selective fisheries in the Columbia River basin, doing so within the time frame necessary to make new marking and selective fishery regimes feasible. The Action Agencies shall initiate studies and/or develop methods by the 3-year check-in.

Even selective fisheries cause some level of incidental mortality on listed fish; obtaining sufficiently accurate and precise estimates of this mortality will be critical to the successful implementation of many selective fisheries. For years, incidental mortalities have been estimated from very limited data. For example, a single estimate of hook-and-release mortalities formerly was used to cover ocean fisheries coastwide, regardless of species or type of hook and line used.

Estimates have improved significantly in recent years, but could be improved even more. The same may be true for mark-selective recreational steelhead fisheries. The weak link in estimating incidental mortalities lies in estimating the encounter rate; existing methods for estimating fishery-specific rates must be improved. In the context of listed fish, where even low levels of mortality can affect the prospects for survival and recovery, accurate and precise estimates of incidental mortalities will be essential for determining the extent to which selective fisheries can accomplish their intended purposes. Studies must be conducted in specific fisheries to better estimate these mortalities as a function, for example, of the type of gear used, how it is fished (e.g., net gear “soak time”), water temperatures, and other variables. Estimating the effects of multiple captures of listed fish is a particularly difficult, but critical-to-solve, problem. Failure to do so could undermine the viability of selective fisheries strategies for some species and/or fisheries. In addition to improving estimates of immediate mortalities resulting from catch and release fisheries, studies are needed to focus on the effects of these encounters on subsequent reproductive success.

9.6.3.3 Procedures for Crediting Reductions in Impacts on Listed Fish

Action 168: The Action Agencies shall work with NMFS, USFWS, and Tribal and state fishery management agencies to develop methods for crediting harvest reforms, and the survival benefits they produce, toward FCRPS offsite mitigation responsibilities. A crediting approach shall be agreed upon by the 3-year check-in.

The methods should identify, for example, how much reduction in take occurs as a result of the reforms. Consideration should be given to the extent to which FCRPS contributes funding for development and application of reform measures. Methods must be included for monitoring and evaluating estimated survival benefits over time. The methods for crediting specific reform measures likely will vary. Allocation of survival benefits enabled by harvest reforms is also likely to vary with circumstances. For example, the survival benefits derived from achieving greater selectivity in a given fishery can potentially be used for either or both of two objectives: 1) achieving a higher catch of nonlisted abundant stocks while staying within a harvest rate limit on listed fish, or 2) further reducing the rate of incidental harvest impacts on listed fish while maintaining a particular level of total catch. It is not possible to maximize both objectives simultaneously, i.e., to minimize impacts on listed fish at the same time as maximizing the catch of nonlisted fish.

In some cases, depending on the status of the listed fish, all survival benefits flowing from greater harvest selectivity should accrue solely to escapements. In other cases, however, a portion of the benefits of greater selectivity could accrue to the fishery as a higher total catch. The Action Agencies and the harvest managers should develop and agree to formulas that accommodate both objectives—increases in escapement and increases in total catch—thereby better aligning the interests of the FCRPS with those of the harvest sector. For action items other than those involving the development and implementation of selective fishery methods

(where it is relatively easy to quantify survival benefits to listed fish), survival credit to the Action Agencies will be more qualitative. An appropriate crediting formula for offsite mitigation for harvest reforms should take into account a number of considerations, including the extent of reductions in take of listed species enabled by the reforms, the reasons the reforms are necessary, the relative responsibilities of the affected parties and actions they have already taken, and the extent to which the Action Agencies contributed to speeding the pace of the reforms, or the margin of safety they provide.

9.6.4 Artificial Propagation Measures

9.6.4.1 Overview

An extensive amount of artificial production of salmon and steelhead occurs in the Columbia River basin today. Many hatchery programs started decades ago specifically to replace natural production lost as a result of the FCRPS and other development, not to protect and rebuild natural populations. The original design and operation of many programs and facilities reflect scientific knowledge and policy decisions of a previous era. Traditionally, the objective of those hatchery programs was to provide harvest opportunities, a mitigation obligation that remains today. Most were never called upon to produce fish that are viable in nature. To a large degree, the programs succeeded in producing harvestable salmon and steelhead to maintain fisheries, even as natural production declined.

In recent years, changing policies reflect the importance of natural populations and the potential negative effects of hatcheries. As many reviewers of the draft opinion noted, numerous artificial production reforms have been implemented. These reforms strive to reduce negative effects of hatchery production on natural populations while retaining its proven production and potential conservation benefits. For example, hatchery programs are in the process of phasing out use of improper brood stocks, such as out-of-basin or out-of-ESU stocks, replacing them with fish derived from, or more compatible with, locally adapted populations. Producing fish that are better suited for survival in the wild is the explicit objective of programs such as the Yakama Nation's Cle Elum hatchery. Many programs incorporate improved production techniques, such as the NATURES rearing program used by the Nez Perce Tribe. The basic thrust of many of these reforms has been to produce fish that pose less risk to natural populations, either by minimizing interactions with natural populations or by making hatchery fish more compatible with them.

Nevertheless, recovery cannot be achieved simply by releasing more hatchery-produced fish in natural production areas, regardless of their ancestry or how they are produced. Hatcheries cannot provide the productive conditions necessary to restore self-sustaining populations in their natural habitats. It is also recognized that some artificial programs and facilities could be further reformed because they still have deleterious effects on natural populations and/or mask their status. The overarching goal of the reforms described here is to reduce or eliminate adverse genetic, ecological, and management effects of artificial production on natural production while retaining and enhancing the potential of hatcheries to contribute to basinwide objectives for conservation and recovery. The goal still includes providing fishery benefits to achieve mitigation mandates, but now must also include an increased emphasis on conservation and recovery, a mission for which many older programs were not designed. Reforms of existing hatchery programs and facilities that began several years ago must be accelerated and broadened to apply a variety of new and improved artificial production techniques that include supplementation, captive brood stock, and other strategies designed to minimize the risk of artificial production and/or maximize its conservation benefits.

These reforms require substantial and costly changes in existing programs and facilities, beginning with a rigorous review of their goals and objectives. An implicit but fundamental premise of the approach described in the Basinwide Recovery Strategy and this biological opinion is that artificial production programs can be operated consistent with, and complementary to the goals of the ESA, while still achieving fishery mitigation objectives. Because there is a range of scientific and policy opinions regarding the purpose and appropriate application of artificial production in specific circumstances, a number of strategies, coupled with an adaptive management approach, are warranted and, with the help of the Action Agencies, are prescribed here.

In applying the ESA to listed species, NMFS focuses on biological requirements. NMFS' understanding of these requirements derives from many sources, including the general conservation literature, specific NMFS studies of salmon, as well as by others, and recommendations of the Tribes, state, and other Federal fish and wildlife agencies and experts. NMFS recently published a compilation of scientific information in "Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units" (McElhany et al. 2000). This document identifies criteria and guidelines relevant to the needs of salmonid populations. Hatchery programs can affect these biological needs. Accordingly, subsequent to the listings, NMFS began to address these programs in biological opinions issued or still in progress under Sections 7 and 10 of the ESA for hatchery programs throughout the Columbia River basin. In those biological opinions, as in this one, NMFS focuses on reducing the deleterious effects of artificial production on listed species. Deleterious effects must be eliminated or reduced enough to avoid jeopardizing listed species and to provide for their survival and recovery. NMFS' biological opinions have led to substantial changes in artificial production programs throughout the region.

In determining the extent of necessary reforms of hatchery programs, and the rate at which they must occur, NMFS considers a number of factors. These include, but are not limited to, the amount of benefit to listed fish accruing from the proposed reform, the extent of improvement already achieved from earlier reforms, the cost of the reforms (both economic and in terms of impacts on other goals and objectives), how quickly they can be implemented, how soon they will produce results, and how well the benefits to the fish can be measured. While all these factors must be considered in hatchery biological opinions, a consistent approach to hatchery reforms should be employed throughout the Columbia River basin, always with the result being a determination that each proposed hatchery program will be operated in a way that does not jeopardize listed fish.

Because the difference between jeopardy and no jeopardy is seldom a bright line, the consultation process also focuses on the margin of safety that artificial production programs should achieve and the pace at which reforms must be implemented. This is an area where the Action Agencies have a substantial opportunity to contribute to the survival of listed species. To the extent that the Action Agencies contribute additional resources (i.e., resources beyond those that they are already obliged to provide to comply with hatchery biological opinions and, thus,

continue to meet their mitigation responsibilities), they can satisfy survival goals within the meaning of this biological opinion.

In addition to reforms of current hatchery programs, another opportunity exists for the Action Agencies to contribute to the survival of listed species. Numerous populations in the upper Columbia and upper Snake river basins are in such bad condition that extinction may be imminent in the near term. Actions in the habitat and hydrosystem sectors designed to improve the status of these populations may not occur due to lack of resources, or may not have the intended effect soon enough to avoid extinction. Given the status and trends of these populations, the potential benefits of intervening with artificial production actions, i.e., safety-net programs, may outweigh the risks of such intervention. The Action Agencies can provide resources to implement such strategies where NMFS determines they are appropriate. Credit should accrue to the Action Agencies for artificial production actions undertaken specifically to avoid extinction, as this clearly constitutes a positive contribution to the survival of the listed populations.

Scientific knowledge regarding the benefits and risks of artificial production is incomplete, but improving. Artificial production measures have proven effective in many cases at alleviating near-term extinction risks, yet the potential long-term benefits of artificial production as a recovery tool are unclear. Scientific uncertainty remains about whether and to what extent hatcheries, as they are currently operated, pose a continuing risk to natural populations. The Action Agencies can further achieve the offsite mitigation goals by investing in research, monitoring, and evaluation to address these uncertainties. These investments may eventually manifest themselves in improved survival of listed fish. NMFS will work with the Action Agencies on a method for recognizing the benefit of these efforts.

A number of studies and reviews of artificial production in the Columbia River basin have occurred in recent years; some are described later in this section. Although their scope is different from NMFS' focus under the ESA and in this biological opinion, their findings and recommendations generally are consistent with the measures identified here. In general, the standards and guidelines that emerge from these reviews are aimed at improving the effectiveness of artificial production programs, minimizing deleterious impacts on natural populations, meshing hatchery production and policies with harvest objectives, and increasing accountability and efficiency in hatchery programs. Integrating hatchery and harvest policies is especially important to meeting obligations for Tribal and non-Tribal fisheries.

9.6.4.2 Actions to Reform Existing Hatcheries and Artificial Production Programs

Recent studies recommending hatchery reform include the NWPPC's Artificial Production Review, several scientific reviews such as the NRC's Upstream Report (NRC 1996), the NWPPC's "Return to the River Report" (ISG 1996), and others found in the literature. NMFS also has published several papers relevant to artificial production, including the Interim Policy on Artificial Propagation of Pacific Salmon under the Endangered Species Act (April 5, 1993, 63

FR 17573), and the previously mentioned VSP report. In general, these studies reach similar conclusions about the types of reforms necessary to reduce deleterious effects while still allowing continued use of hatchery production to provide Tribal and non-Tribal harvest opportunities.

The detrimental impacts of artificial production can be categorized into 1) genetic effects resulting from domestication, artificial selection, inbreeding, straying, and stock transfers; 2) ecological interactions such as competition and predation; and 3) management effects, such as occur when fisheries are managed at high rates to take hatchery fish, resulting in excess harvest of natural fish. In addition, there is the masking effect of hatchery fish that confounds NMFS' ability to determine the status of natural populations. While many hatchery reforms have been or are in the process of being implemented, much remains to be done.

From the recent studies, a fairly extensive menu of measures has been identified, and specific actions to implement the measures have emerged. This does not imply that they are all ready to go. In fact, the process of hatchery reform involves a systematic review, program-by-program and hatchery-by-hatchery, to determine on a case-by-case basis which of the measures and actions to apply and when and how they should be implemented. The actual implementation of these measures and actions, whether they involve capital expenditures, operation and maintenance improvements, staffing, and/or other matters constitutes what is meant by artificial production reform throughout this opinion. Efforts to apply these reforms, already underway in many cases, must be expanded and accelerated to programs and facilities throughout the Columbia River basin. Hatchery reform should occur within a broader context of planning in the Columbia River basin designed to clarify goals, objectives, and performance criteria of a basinwide approach for all species to improve accountability and effectiveness. This broader approach includes the development of subbasin plans for management of all species and recovery plans for listed species. They will include, among other things, a better integration of hatcheries and harvest objectives and strategies. The menu of reform measures and actions is represented in the following list:

- Reform measures to clarify the goals, objectives, and performance criteria of hatchery programs to improve accountability and meet subbasin and recovery plan objectives:
 - Develop, clearly articulate, and commit to specific artificial propagation plans.
 - Identify and implement specific monitoring and evaluation protocols at all relevant scales (i.e., varying from basinwide to facility-specific protocols).
 - Apply adaptive management principles by linking future activities to research, monitoring, and evaluation outcomes.
- Reform measures to manage genetic risks to listed species and meet subbasin and recovery plan objectives:
 - Discontinue interbasin transfers of stocks.
 - Phase out inbred, domesticated, and inappropriate composite broodstocks.

- Produce fish derived from locally adapted stocks to the extent feasible and appropriate.
 - Employ mating protocols designed to avoid genetic divergence from the biologically appropriate population.
 - Manage the number of hatchery-produced fish that escape to spawn naturally, employing limits that will vary depending on the origin of the broodstock, the management objective, and the status of the affected natural populations.
 - Employ hatchery practices that reduce unwanted straying of hatchery fish, for example by acclimating them to desired return areas.
- Reform measures to manage ecological risks to natural populations and meet subbasin and recovery plan objectives:
 - Minimize competition between hatchery and natural fish, for example, by avoiding production that exceeds the carrying capacity of limiting habitats.
 - Minimize predation and other negative interactions between hatchery and natural fish, for example, by producing fish similar in size, behavior, and life history characteristics to the naturally produced fish in the same waters.
 - Reform measures to improve hatchery effectiveness and meet subbasin and recovery plan objectives:
 - Design hatchery facilities to mimic natural incubation and rearing conditions.
 - Design facilities for acclimation and release of smolts to improve homing fidelity.
 - Reform measures to avoid management risks associated with hatchery production and meet subbasin and recovery plan objectives:
 - Design, implement, monitor, and evaluate the hatchery program consistent with a comprehensive restoration plan.
 - Design and conduct fishery augmentation programs so that fish can be harvested without undue impacts on weaker runs.
 - Mark hatchery-produced fish to distinguish natural from hatchery fish on spawning grounds, in dam counts, and in fisheries.

To facilitate the application of hatchery reforms to specific artificial production programs and projects, NMFS supports what is called a hatchery and genetic management plan (HGMP). NMFS developed the HGMP in collaboration with other Federal agencies, states, and Tribes. It provides a standardized approach and a consistent body of relevant information about artificial production programs. A NMFS-approved HGMP contains a clear statement of the purpose and goals of the program or project and its relationship to harvest and other management goals. It comprehensively addresses facility and operational details relevant to reform measures and action items identified above. It requires that an appropriate monitoring and evaluation plan be developed and implemented for that facility or program. Research critical to the success of the project must also be identified.

NMFS considers an approved HGMP to be a necessary step in assessing artificial propagation programs. It is anticipated that HGMPs will evolve over time into more comprehensive and detailed documents as additional focus and resources are brought to bear on hatchery reform and as new information becomes available.

The development of NMFS-approved HGMPs is a substantial task that must be completed before many actual reforms can be implemented. Additionally, the process of hatchery reform does not end with a completed NMFS-approved HGMP. Rather, hatchery reform will be a continuing process of implementing, monitoring, evaluating, and revising the HGMP plans. Priority should be assigned to circumstances that affect populations in the most critical condition.

There is also an immediate need to enable differentiation between hatchery and naturally produced salmon. As explained in the critical research section, uncertainty about the number of hatchery-origin versus natural-origin fish on the spawning grounds confounds our ability to assess and monitor natural population status and growth rates. This masking problem can be addressed by marking hatchery production, but must also include improved sampling efforts and specific experiments (e.g., radio tagging) to determine relative distribution and timing of hatchery and natural spawners. It is particularly urgent to mark the most at-risk species such as spring chinook and steelhead.

Action 169: The Action Agencies shall fund the development of NMFS-approved HGMPs for implementation, including plans for monitoring and revising them as necessary as new information becomes available. HGMPs have to be completed first for the facilities and programs affecting the most at-risk species (Upper Columbia and Snake River ESUs), followed by those affecting mid-Columbia, and then the Lower Columbia ESUs. HGMPs for all the Columbia basin hatchery programs and facilities should be completed (and approved by NMFS) by the 3-year check-in.

Action 170: Using new authorizations and appropriations and/or BPA funds as necessary and appropriate, the Corps, working with USFWS, shall oversee the design and construction of capital modifications identified as necessary in the HGMP planning process for Lower Snake River Compensation Plan anadromous fish hatchery programs. These improvements shall begin immediately after the relevant HGMPs are completed and approved by NMFS, and shall be completed as expeditiously as is feasible. BPA shall provide for the operations and maintenance costs of these reforms and shall reimburse the Federal Treasury for an appropriate share of the capital costs. The Corps shall have begun to implement reforms for programs affecting the most at-risk species by the 3-year check-in.

Action 171: BOR shall implement the reforms identified in the HGMP planning process for the Grand Coulee mitigation anadromous fish hatchery programs, beginning

immediately following completion of the relevant (NMFS approved) HGMPs and completing the work as expeditiously as feasible. BPA shall fund the operations and maintenance costs of the reforms and shall reimburse the Federal Treasury for an appropriate share of the capital costs. BOR shall have begun to implement reforms for programs affecting the most at-risk species by the 3-year check-in.

Action 172: The Corps shall implement the reforms identified in the HGMP planning process for the Corp's Columbia River basin mitigation anadromous fish hatchery programs, beginning immediately after the relevant HGMPs are completed and are approved by NMFS. The work shall be completed as expeditiously as feasible. BPA shall fund the operations and maintenance costs of the reforms and shall reimburse the Federal Treasury for an appropriate share of the capital costs. The Corps shall have begun to implement reforms for the programs affecting the most at-risk species by the 3-year check-in.

Action 173: BPA shall implement the reforms identified in the HGMP planning process for Federal and Federally funded hatcheries, beginning immediately after the relevant HGMPs are completed and approved by NMFS. The work shall be completed as expeditiously as possible. BPA shall have begun to implement reforms for the programs affecting the most at-risk species by the 3-year check-in.

BPA is currently responsible for the power-allocated share of O&M and capital costs associated with reforms that will be required under hatchery biological opinions. To the extent that the Action Agencies seek credit for reforms above and beyond this level, appropriate cost-sharing arrangements will have to be worked out between them and other entities involved in funding the particular hatchery program.

Funding for necessary reforms at Mitchell Act facilities will be sought through congressional appropriations. To the extent that such additional appropriations are not forthcoming, or are insufficient to accomplish all needed reforms as rapidly as possible, however, offsite mitigation crediting could occur at any artificial production facility if the Action Agencies make funds available for that purpose.

Action 174: Working through regional prioritization processes to the extent feasible and in coordination with NMFS, BPA shall collaborate with the regional, state, Tribal, and Federal fish managers and the Pacific States Marine Fisheries Commission to enable the development and implementation of a comprehensive marking plan. Included in this action are the following four steps:

1. Develop a comprehensive marking strategy for all salmon and steelhead artificial production programs in the Columbia River basin by the end of 2001.

2. Provide funding by March 1, 2001, to begin marking all spring chinook salmon that are currently released unmarked from Federal or Federally funded hatcheries.
3. Provide funding, beginning in FY 2002, to implement the Action Agencies' share of the comprehensive marking plan for production not addressed in (2) above.
4. Obtain funding contributions as appropriate for additional sampling efforts and specific experiments to determine relative distribution and timing of hatchery and natural spawners.

9.6.4.3 Actions to Create an Artificial Propagation Safety-net Program

As noted previously, a number of salmon and steelhead populations in the upper Columbia and Snake river basins are at particularly depressed levels, with many facing a high risk of extinction in the near term. For many of these, new safety-net projects designed to intervene with artificial production techniques may be appropriate to prevent extinction. Designed only to prevent extinction, these are not intended to be permanent projects, and they do not serve as substitutes for addressing the factors of decline.

A four-step process will generally be applied to an individual population being considered for a safety-net project, starting with an extinction risk analysis to identify populations that are candidates for intervention. Second, intervention options will be developed, and a proposed strategy will be outlined. Third, a benefit-risk analysis for the proposed strategy will be conducted to determine whether intervention is warranted. Fourth, an HGMP will be developed to guide implementation of the safety-net project. Planning for a safety-net program must be conducted on an accelerated basis so that, if warranted, the project can be implemented expeditiously. The planning process will necessarily rely on available information that will vary significantly between populations and species. The purpose of the safety-net program will not be achieved, and additional populations may go extinct, if the process suffers from excessive delay, or awaits additional information that may not exist or be available for some time.

A factor that clearly will affect the scope of the safety-net program over time is future environmental conditions, especially ocean conditions. If environmental conditions improve significantly, the number of populations needing safety-net interventions will decrease. Alternatively, if environmental conditions remain poor or worsen, then more populations will require intervention to arrest further decline in abundance. Given the high costs involved, and the uncertainty over future environmental conditions, and the considerable uncertainty of the benefits and risks of intervention, the safety-net approach necessarily and appropriately will involve a mix of strategies. Some projects should begin as soon as possible, while others will not occur unless populations continue to decline. Safety-net projects may be as intensely intrusive as the Stanley Basin sockeye recovery program, which anticipated taking the entire

population into a captive broodstock program for several years. Others may involve short-term interventions for one or two generations, using more conventional artificial propagation methods such as supplementation using appropriate broodstocks. Preferably, intervention will occur before a population declines to the point that highly intrusive techniques are necessary.

Additional work is needed to identify candidates for the safety-net program, but the individual populations identified below are currently thought to warrant intervention. All are located in the Snake River basin, and some intervention may already have begun. Although some of the most at-risk populations are in the upper Columbia River, the immediate safety-net needs in that area are being addressed pursuant to existing and planned processes tied to non-FCRPS mitigation programs, including commitments from the mid-Columbia PUDs. The need for additional safety-net actions in any part of the Columbia and Snake river basins, and the FCRPS' responsibility to support those actions, depend on future assessments of population status.

Action 175: BPA shall, in coordination with NMFS, USFWS, and the relevant state and Tribal comanagers, fund the four-step planning process described above as quickly as possible and, if so determined by that process, implement safety-net projects as quickly as possible at least for the following salmon and steelhead populations: 1) A-run steelhead populations in the Lemhi River, main Salmon River tributaries, East Fork Salmon River, and Lower Salmon River; 2) B-run steelhead populations in the Upper Lochsa River and South Fork Salmon River; and 3) spring/summer chinook populations in the Lemhi, East Fork, and Yankee Fork Salmon rivers, and Valley Creek.

This action item should be included in a package of early implementation projects. The required planning process should be completed by the end of 2001 so implementation of high-priority, safety-net actions can begin with brood year 2002. [Note: the populations identified in this action item are consistent with those identified by the Tribes on the "A" list of projects.]

Action 176: BPA shall, in coordination with NMFS, USFWS, and the relevant state and Tribal comanagers, fund the development of HGMPs for the Grande Ronde and Tucannon spring/summer chinook safety-net programs.

Based on previous risk assessments, conservation hatchery programs consistent with the safety-net concept already have begun for three populations of spring/summer chinook on the Grande Ronde River and for the single Tucannon River population. Portions of these programs have been accommodated temporarily, but unsatisfactorily, by crowding into existing facilities, with resultant compromises with other ongoing programs. Each conservation hatchery program would benefit from development of an HGMP that identifies the capital and operational needs for these programs and implementation of the HGMP's findings. The Nez Perce Tribe and Confederated Tribes of the Umatilla Indian Reservation are well along in planning for the North East Oregon Hatchery. Coordination between the existing LSRCP safety-net program and North East Oregon Hatchery planning processes is already occurring to a large degree and should

continue among USFWS, NMFS, the states of Oregon and Washington, and the Tribes to provide the best, most efficient and expedient, integration of hatchery programs to meet the resource needs of this region. This safety-net action item should be completed by the end of 2001 to accommodate facility development beginning in 2002.

Action 177: In 2002, BPA shall begin to implement and sustain NMFS-approved, safety-net projects.

This action funds the actual implementation and operation of safety-net projects. Depending on the planning results, specific measures may include funding modifications to existing facilities, or construction and operation of new facilities. The obligation to fund the safety-net program, including O&M, monitoring, and evaluation, will continue indefinitely, as circumstances warrant.

Action 178: BPA shall commit to a process whereby funds can be made quickly available for funding the planning and implementation of additional safety-net projects for high-risk salmon and steelhead populations NMFS identified during the term of this biological opinion.

Additional safety-net interventions to prevent extinction of listed populations may be required in the future. The annual offsite mitigation planning process discussed in Section 9.4 (development and implementation of 1- and 5-year plans) may be the appropriate mechanism for providing urgent and quickly needed resources for these interventions. NMFS and USFWS will work with BPA to begin the four-step planning process described above for populations that may require intervention, but that were not addressed in the initial round of projects. Depending on the outcome of the additional assessments and future environmental conditions, resources may be urgently needed for additional populations.

In rare cases, there may be emergency actions that need immediate response, such as unforeseen catastrophic events. In these cases, it may not be possible to wait to complete the HGMP planning process, but will require funding for immediate intervention. In anticipation of these situations, NMFS will work with BPA and the fishery comanagers to devise an appropriate strategy.

9.6.5 Research, Monitoring, and Evaluation Plan

The research, monitoring, and evaluation program that is part of this biological opinion must encompass both the entire salmonid life cycle and the different management areas through which fish pass. This RPA calls for actions affecting fish survival in the hydropower corridor, in tributary habitat, and in the estuary and nearshore ocean environment. In addition, actions in one management arena (other life stages and Hs) may affect the outcomes of FCRPS actions in the hydrosystem corridor (and vice versa). Due to the variety of actions and potential interactions between them, determining the effectiveness of the suite of actions in this RPA will require that a comprehensive (Basinwide Recovery Strategy) monitoring and evaluation program be developed (see action below). Equally important, the performance measures and standards to which actions are being held cannot be determined or judged appropriately in the absence of such a program. Therefore, in the context of this biological opinion, research, monitoring, and evaluation must address five areas:

Population status monitoring. This consists of determining what areas are occupied by juvenile salmonids and spawning adults, assessing the status of the population (i.e., abundance, trend, distribution, and variation), and reviewing status changes through time. Population status monitoring will also provide a baseline against which management actions can be assessed.

Environmental status monitoring. This consists of assessing environmental influences, including non-native species, potentially affecting salmonid populations, and determining whether they change through time, if associations occur between environmental attributes and salmonid population status, and whether these associations suggest that particular management actions should be studied further. Environmental status monitoring will also provide baseline information against which the effectiveness of management actions can be assessed.

Effectiveness monitoring. This consists of assessing whether management actions have the intended effects on the aquatic system and the response of salmonid populations to those effects.

Quality of regional databases. This consists of assessing the accuracy and comprehensiveness of currently available databases that represent habitat quality throughout the basin. This will play an important role in prioritizing what habitat actions should be implemented in which locations.

Compliance monitoring. This consists of assessing whether management actions have been properly implemented and maintained (see also Section 9.6.2).

Overall survival through the life cycle (annual population growth rate) will be a critical measure assessed in the research, monitoring, and evaluation program. Annual population growth rate is a fundamentally important measure of population health. Its use is advisable for the following reasons:

- Use of a population growth rate allows a more biologically meaningful assessment of the effectiveness of an action (or actions) than population size.
- The collective effect of all management actions that serve to improve population health, even if indirectly, can be assessed via growth rate.
- Given that trends or growth rates will be included in recovery goals, it is simple to determine the change in population growth trajectory needed to meet the target and the probability of detecting the effect of actions in a set time frame.

Due to the normal salmonid return times and naturally high variability in salmonid populations, however, it will be difficult to detect population responses using life-cycle response alone. In addition to current juvenile survival monitoring, therefore, the following must have high priority for monitoring and evaluation:

- Developing short-term measures of stock performance that can serve as proxies for standard metrics such as recruits per spawner
- Developing short-term measures of stock performance that focus on the life history stages identified as critically important to population growth in the cumulative risk initiative analysis, i.e., egg-to-smolt, estuarine, and early ocean growth, as well as survival

These short-term measures will determine salmon population growth and, as such, will provide explicit links between population processes and the condition of salmonid habitat. They will also contribute to the performance standards necessary to continually reassess the assumptions inherent in the opinion about the potential gains through offsite mitigation.

Discrete hypothesis testing and resolution of critical uncertainties are very important in the near term to assess the status of the ESUs. They should be central elements of research in the annual plan and will enable determining the measures needed to enhance species survival and recovery in the ESUs. For example, understanding the extent and reproductive success of natural spawning of hatchery fish and the delayed mortality of fish passing dams, either by transportation or inriver, are critical needs. Such information is needed to form meaningful conclusions in the other categories of monitoring and evaluation described above. Progress on resolving these uncertainties is a primary consideration in the biological opinion, for annual and 5-year planning, and for the 5- and 8-year check-ins.

The following sections describe elements of a research, monitoring, and evaluation program that the Action Agencies will implement under this RPA. First, a framework for population identification and establishing recovery goals is provided (Section 9.6.5.1). Second, general principles and guidelines for assessing population and environmental status are described (Section 9.6.5.2). This section includes a discussion of specific site sampling in two levels of detail, or tiers. Section 9.6.5.3 describes a general scheme for effectiveness monitoring and lists,

in detail, a number of studies essential for resolving critical uncertainties in the areas of population status, tributary habitat, hatchery management, the hydrosystem corridor, and the estuary/nearshore life-history stages. FCRPS activities and offsite mitigation affect all these areas. Compliance monitoring is addressed both in this section and in Section 9.6.2.

The research, monitoring, and evaluation actions specified in this section are intended to address the need to evaluate the species' status, environmental status, and response to management actions. Such a complete monitoring program is also necessary to establish performance standards and appropriately allocate changes in population status to management actions or environmental conditions. The FCRPS agencies and other Federal and non-Federal entities are expected to contribute to this comprehensive monitoring. The FCRPS agencies are responsible for monitoring and evaluating their actions under the RPA in this biological opinion, as amended by annual and 5-year plans, as well as providing for baseline monitoring necessary to detect changes in population or habitat trends. NMFS anticipates that the cost and implementation of the research, monitoring, and evaluation will be shared among these entities, commensurate with their responsibilities, and will be coordinated through applicable regional processes.

The Action Agencies shall continue or start work on the actions in this RPA concurrent with developing the research, monitoring, and evaluation plan. Actions are not limited to those outlined below if agreement is reached that other actions address critical uncertainties and should begin before the research, monitoring, and evaluation plan is completed. NMFS anticipates that the plan outlined below, and in Appendix G, will be followed, but that it may be modified by identification of other priority actions agreed to by the Action Agencies. The plan may also be modified through the development of the 1- and 5-year implementation plans.

9.6.5.1 Population Identification and Establishment of Recovery Goals

Action 179: The Action Agencies and NMFS shall work with affected parties to establish regional priorities within the congressional appropriations processes to set and provide the appropriate level of FCRPS funding to develop recovery goals for listed salmon ESUs in the Columbia River basin. Tasks shall include defining populations based on biological criteria and evaluating population viability in accordance with NMFS' viable salmonid population approach. These tasks shall be completed by 2003.

Biologically based populations must be defined to establish recovery goals for listed ESUs. Assessing population status (or viability) will be important to gauge needed changes and progress toward those goals. This effort will include assessing genetic differentiation (allele frequencies), environmental and habitat characteristics, life history and morphological traits, demographic information, estimates of straying or migration, and geographic distribution. The Action Agencies will obtain these data for all jeopardized ESUs in the Columbia River basin.

The technical recovery teams will be responsible for developing specific recovery goals by assessing the data compiled through the research, monitoring, and evaluation efforts described above. The Interior Columbia Basin Technical Recovery Team will be convened by late spring 2001 to address recovery planning for all listed ESUs in the interior Columbia River basin. It will probably include separate subgroups to focus on the Snake, Upper Columbia, and Middle Columbia rivers. A separate Willamette and Lower Columbia River Technical Recovery Team has already been formed. Once technical recovery teams convene, tasks should be completed within 18 months. The specific timeline for the relevant tasks is shown in Table 9.6-4. Data collection during ongoing subbasin assessment processes will facilitate this action.

Ultimately, NMFS will describe recovery goals in its recovery plans. As this portion of the plans becomes final, NMFS will use the goals in its analysis of agency actions, and the Action Agencies will take the recovery goals into account in their annual plans for the FCRPS. If the goals entail major changes in analyses or actions, the Action Agencies may have to reinstate consultation.

Table 9.6-4. Timeline of tasks for establishment of recovery goals.

Task	Product(s)	Completion Date
1. Identify populations.	Population list	Months 3-4
2. Characterize populations (historical and current) based on the following:	Population list with characteristics (a-d).	
a. Abundance/productivity		Months 4-6
b. Diversity		Months 4-6
c. Spatial structure		Months 4-6
d. Habitat capacity		Months 9-10
3. Estimate viability of populations.	Population list with viability status (a-c) and criteria for achieving (if not presently viable)	
a. Abundance/productivity		Months 11-12
b. Diversity		Months 11-12
c. Spatial structure		Months 11-12
4. Provide scenarios that achieve ESU-level viability.	Description of each population's characteristics (a-c above) necessary for ESU viability (multiple scenarios)	Months 12-18
5. Identify factors for decline.	Critical life-stage list	Months 14-15
	Potential factors affecting mortality at different stages	Months 15-18

9.6.5.2 Population Status and Environmental Status Monitoring—Tiers 1 and 2

Action 180: The Action Agencies and NMFS shall work within regional prioritization and congressional appropriation processes to establish and provide the level of FCRPS funding to develop and implement a basinwide hierarchical monitoring program. This program shall be developed collaboratively with appropriate regional agencies and shall determine population and environmental status (including assessment of performance measures and standards) and allow ground-truthing of regional databases. A draft program including protocols for specific data to be collected, frequency of samples, and sampling sites shall be developed by September 2001. Implementation should begin no later than the spring of 2002 and will be fully implemented no later than 2003.

The region will deploy a hierarchical monitoring program in both freshwater and estuarine systems. Appendix G outlines this program, and Table 9.6-5 summarizes the entire monitoring scheme. The monitoring program, including sampling protocols, will be developed by a collaborative effort of the Northwest Forest Science Lab and other regional agencies with monitoring expertise. The participants should have experience implementing comprehensive monitoring and evaluation programs and should include the EPA, the Oregon Coastal Salmon Restoration Initiative, and the Abernathy Fish Technology Center. Technical Recovery Team participation in this process will also be vital, since these data will provide the basis for implementing and confirming specific recovery plan actions. NMFS anticipates that state, Tribal, and local agencies, with Action Agency funding, will have primary responsibility for data collection in this program. The portion of this program implemented in the estuary and nearshore ocean environments must also be coordinated with the Conservation Reserve Enhancement Program, the Columbia River Estuary Study Task Force, and the Corps' analysis of the feasibility of altering flood control rule curves and operations to address mainstem flow objectives.

At a minimum, monitoring developed and conducted under this action will include the two levels of detail, or tiers, outlined below (and in Appendix G) in both freshwater and estuarine/nearshore ocean environments. Performance standards will be defined in terms of measures at both these tiers, enabling future assessment of recovery progress. Data collected at these tiers will also contribute to the Technical Recovery Team process. Specific details of the scheme, such as the distribution of sampling sites, protocols, or procedures to adapt monitoring programs, will be developed during the monitoring and evaluation program development process.

Tier 1. Tier 1 site sampling is the broadest of the sampling levels, comprising the greatest number of sites, sampled at the lowest frequency. It is designed to give the broadest picture of salmonid population status and the condition of the habitats in which they are found. Tier 1 data will contribute to population and environmental status monitoring, database quality, and compliance monitoring. It can contribute to effectiveness monitoring when the expected population response is range expansion. Specific goals associated with this tier are as follows:

Table 9.6-5. Outline of proposed monitoring and evaluation sampling design.

	Tier 1	Tier 2	Tier 3	Landscape imagery	Compliance logbook
Sampling frequency	Once every 3-4 years	Annually	Frequency dependent upon study; minimum annually	Once every 3 years	Once every 6 months (action agency); arbitrarily to monthly (regulatory agency)
Relevant to monitoring types*	1,2,3,4,5	1,2,3,4,5	3,5	2	5
Goals [#]	A, B	B, C	C, D	B	
Number of sites	To cover all potentially used areas in a population	To be determined by power analyses	Minimum three per ESU; minimum two for each major management action	Entire Columbia Basin	All management actions
Data type -- salmonid population	Presence/absence	Counts of juveniles and spawners	Dependent on management action; Hatchery spawner reproductive success	None	None
Data type -- habitat	General, qualitative	Qualitative and quantitative	Quantitative, dependent on management action	Landscape-level attributes	None

*Relevant to monitoring types: 1 = population status monitoring, 2 = environmental status monitoring, 3 = effectiveness monitoring, 4 = quality of regional databases, 5 = compliance (implementation) monitoring

Goals: a = establish fish habitat use or range; b = establish associations between environmental characteristics and population status; c = estimate population growth rates or stage-specific survival rates; d = establish mechanistic links between management actions and salmon population response.

- Define areas currently used by adults and juveniles.
- Detect altered status of populations due to range expansion or shrinkage.
- Identify associations between salmon presence and habitat attributes.
- Ground-truth regional habitat quality databases (used in prioritizing management actions and areas for those actions).

Tier 1 sites will be sampled on a 3- to 4-year rotation, with each site being sampled once in that time period. Sites will be distributed to sample the full range of habitats in the area potentially

occupied by the population of interest. Distribution should be stratified by channel type, but other stratification may be necessary. A seasonal component will be important, particularly for juvenile surveys, to determine habitat use and availability at different times of the year.

In the estuary, Tier 1 sites will contribute to NMFS' understanding of juvenile salmonid usage of the lower river mainstem, side channel, and estuarine habitats. Of special importance is the extent to which restoring shallow-water estuary habitat might mitigate the additional flood risk resulting from altered rule curves. In addition, this sampling will contribute to developing appropriate indicators of physical and biological change that connect FCRPS flow management operations to the estuarine conditions of salinity, temperature, and suspended particulate matter.

Tier 2.

Tier 2 site monitoring will give a more detailed picture of population status and will allow researchers to assess relationships between environmental characteristics and that status. Tier 2 data will form the backbone of population and environmental status monitoring. It may also contribute to effectiveness and compliance monitoring. Tier 2 data can also be used to compare the status of different populations. Data collected will also function as performance measures (see Appendix G).

For freshwater systems, specific tier 2 goals are defining population growth rates, detecting changes in those growth rates or in relative abundance in a reasonable time, estimating juvenile freshwater abundance and survival rates, and identifying associations between population status or stage-specific survival and environmental attributes (particularly with changes in those attributes over time).

Specific goals associated with tier 2 sampling in the estuary are estimating relative smolt abundance in estuarine/nearshore ocean environments and survival rates during the estuarine phase, detecting changes in relative abundance and survival rates between years, identifying associations between changes in rates of smolt abundance (or survival) and environmental attributes, and identifying associations between history (dam passage route) or parentage (wild versus hatchery) and smolt abundance or survival rates.

Tier 2 sites will be sampled annually. The number of sites to be sampled in each life stage or habitat will be determined by a power analysis. ESUs made up of populations that fluctuate widely will require more tier 2 sites than ESUs with less variable spawner counts. Sites will be distributed probabilistically within a population, ensuring that both good and bad sites are appropriately represented. Some stratification may have to be included (i.e., channel type) in site distribution to obtain the best data.

Juvenile and spawner or redd counts will ultimately provide a measure of egg-to-smolt survival. This will improve estimates of population growth rate and can serve as a baseline for other monitoring efforts (see tier 3).

Action 181: The Action Agencies and NMFS shall work within regional prioritization and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for a program to acquire and digitize aerial or satellite imagery of the entire Columbia River basin once every 3 to 5 years.

Watershed or sub-watershed level data are critical to prioritize areas for management actions. In addition, these types of data can provide a baseline against which to measure management actions. Finally, large-scale data can contribute to analyses of associations between potentially important watershed-level characteristics and salmon population status. However, much of the relevant large-scale data is not appropriately collected on the ground. This landscape-level data collection will allow a more detailed assessment of land use and land cover variables than is currently available for the region. In addition, the repeated assessment of the variables through time will allow changes in environmental characteristics to be associated with changes in salmonid population status. These data will have value for resource and wildlife management well beyond listed salmon species.

9.6.5.3 Detailed Studies and Effectiveness Monitoring—Tier 3

Several more specific studies, in addition to those outlined in Section 9.6.5.2, will be needed to assess the impact of the management actions undertaken in this RPA and compliance with performance standards. In particular, effectiveness monitoring for hydropower corridor actions, effects of hydropower actions outside the corridor, and effects of offsite mitigation will be critical for determining performance standards. In addition, reducing the uncertainty around the reproductive success of naturally spawning hatchery fish (and, therefore, the current status of wild populations) will require more detailed study.

NMFS anticipates that the Technical Recovery Teams, while coordinating efforts with monitoring and evaluation program development, will prioritize actions and populations for effectiveness monitoring or other detailed study. Below, general guidance for third tier (more detailed) monitoring is outlined. Following that, specific studies that are in progress, that address established critical uncertainties, or that are important to initiate immediately are described in more detail. They fall in the areas of population status, habitat, hatcheries, and hydropower effects on migration, the estuary, and nearshore ocean. The studies described below are those that are not directly associated with a single action (a specific passage improvement, for example), but that are associated with indirect or multiple effects, or more general actions. Monitoring associated with a particular action is described with that action.

9.6.5.3.1 Detailed Studies—General Considerations

Effectiveness monitoring and other more detailed studies can be considered a third tier of a comprehensive monitoring program. To be most effective, these studies must be conducted within an explicit experimental (hypothesis-testing) framework, including both treatment and control sites.

The experimental design of each study will be determined by a variety of factors. When possible, however, these studies should be conducted in the context of a before-and-after control impact (BACI) design, which incorporates temporal and spatial controls, allowing environmental impacts such as ocean cycles to be filtered out. Studies conducted under tier 1 and tier 2 monitoring programs will aid in identifying the important variables by which control and treatment sites should be paired or stratified. Information from other monitoring tiers (especially tier 2) will also provide important controls against which changes in tier 3 studies can be assessed.

Specific sites for these actions (and for controls for those actions) should be identified by considering important environmental factors (or strata), but pragmatic concerns may play a role in choosing some sites. For instance, historically sampled index stocks will be especially valuable contributors to the tier 3 network because their historical time-series offers special opportunities for distinguishing responses to management from chance fluctuations. Local groups may also plan and fund management activities that provide opportunities for detailed effectiveness monitoring.

While the specific data to be collected at this third tier will be tailored to the management action being studied, some general guidelines should be followed. For instance, each study must assess appropriate age-specific survival. In many cases, this may involve several life stages. Sediment reduction, for example, may affect both egg-to-fry and fry-to-smolt survival rates. Whenever possible, PIT tags or other individual marking techniques should be used to follow the fates of individual fish as a function of their history. Such individual studies are important for identifying the effects of environmental conditions that are realized at later life stages. Similarly, size or growth rates, as well as demographic rates, may be important parameters in these studies. In addition, both habitat and population response to the management action should be assessed to identify the factors causing any fish population responses. Finally, as above, appropriate control sites must be paired with the treatment sites to establish unambiguous causal links between actions and environmental or salmon population responses.

9.6.5.3.2 Population Status, Tier 3—Reproductive Success of Naturally Spawning Hatchery Fish is a Critical Uncertainty

Action 182: The Action Agencies and NMFS shall work within regional priorities and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for studies to determine the reproductive success of hatchery fish relative to wild fish. At a minimum, two to four studies shall be conducted in each ESU. The Action Agencies shall work with the Technical Recovery Teams to identify the most appropriate populations or stocks for these studies no later than 2002. Studies will begin no later than 2003.

Naturally spawning hatchery fish mask the population trajectory of wild populations. This masking not only obscures population status, but also makes it difficult to determine population

goals and performance standards with certainty. These studies should identify both the genetic contribution of hatchery-origin spawners to subsequent generations and the temporal and spatial distribution of those spawners.

9.6.5.3.3 Habitat, Tier 3—Effectiveness Monitoring

Because offsite mitigation is required as part of this RPA, and habitat performance measures will be assessed, habitat effectiveness monitoring is necessary. Objectives for this monitoring should be set at a subbasin or smaller scale. Habitat research areas should be identified by assessments and should include management or project actions of greatest potential significance to salmonid productivity in that region. The subbasin assessment template should provide the background context to identify specific monitoring objectives for each region.

In addition, critical information can be gained by initiating experimental studies on readily identifiable general classes of habitat improvement actions. Monitoring and evaluation studies should be initiated in the first 2 years to take advantage of selected opportunities to gain information on the effectiveness of these types of actions in terms of physical standards and juvenile survival criteria or standards (e.g., egg-to-parr survival, egg-to-smolt survival). Study design and selection should take into account the relative change in survival expected in a particular setting, the existence of baseline information, and the ability to detect improvements over the range of life history patterns (e.g., upstream and downstream rearing areas).

Action 183: Initiate at least three tier 3 studies (each necessarily comprising several sites) within each ESU (a single action may affect more than one ESU). In addition, at least two studies focusing on each major management action must take place within the Columbia River basin. The Action Agencies shall work with NMFS and the Technical Recovery Teams to identify key studies in the 1-year plan. Those studies will be implemented no later than 2003.

Each major habitat or hatchery management action should be assessed immediately to obtain enough information for a complete evaluation at the 5- and 8-year check-in points. Management actions falling in this category include the following:

- Attainment of minimum instream flows
- Compliance with water quality standards
 - Alteration of grazing practices
 - Reduction of sediment through road closures
- Enhanced levels of marine-derived nutrients
- Improved riparian conditions
 - Alteration of grazing practices
 - Active stream restoration

9.6.5.3.4 Hatchery, Tier 3—Effectiveness Monitoring

Action 184: The Action Agencies and NMFS shall work within regional prioritization and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for a hatchery research, monitoring, and evaluation program consisting of studies to determine whether hatchery reforms reduce the risk of extinction for Columbia River basin salmonids and whether conservation hatcheries contribute to recovery.

This action item is intended to address the overall research, monitoring, and evaluation needs for artificial propagation in the basin. It exceeds research, monitoring, and evaluation needs associated with specific hatchery programs, projects, or facilities that derive from HGMPs. Reform measures and associated actions are described in Section 9.6.4.2. A conceptual framework for conservation hatcheries is also described by Flagg and Nash (1999).

Initially, the objectives for hatchery research, monitoring, and evaluation will include identifying and evaluating current hatchery production goals and level of effort and ensuring that the goals and level of effort are appropriate to the ecological and genetic effects of hatchery production in the local system. This assessment has several components, including the following actions:

- Estimate (if possible) the carrying capacities of rearing habitat and the migration corridor.
- Determine numbers of naturally spawning first-generation hatchery fish (i.e., hatchery escapement).
- Determine the relative reproductive success of naturally spawning hatchery fish compared to those of wild origin.
- Monitor the size, age, health, and smolt quality (growth), as well as release locations, timing, and life stages of hatchery fish.
- Assess (if possible) the frequency and magnitude of ecological interactions between hatchery and wild fish.
- Assess the genetic variability of populations and metapopulations.

Given these elements of the biological context in which each hatchery program exists, it will be possible to design and/or improve upon hatchery protocols. The goal of hatchery reforms is to reduce or eliminate adverse genetic, ecological, and management effects of hatchery production on natural populations to meet basinwide objectives for conservation and recovery. Thus, the concomitant research, monitoring, and evaluation program would assess the following aspects of natural populations:

- Reduced genetic variation
- Potential transfer of genetic traits from hatchery to wild stock
- Reduced genetic population structure
- Increased ecological interaction with hatchery fish (competition, predation, and disease)
- Masking of natural population status by the presence of naturally spawning hatchery fish

Ultimately, the monitoring and evaluation program must identify hatchery and natural population interactions and isolate their effects on the growth rate of natural populations. To do so, the evaluation program must consider the cumulative effects of hatchery production across the appropriate subbasin, as well as throughout the entire life cycle of the fish. This will require that a relationship be developed between the productivity of the natural populations (as represented, for example, by λ) and the total production of hatchery fish, which will depend on such factors as survival and productivity during freshwater rearing and seaward migration, ocean residence, and return. Such assessment will provide the statistical power to detect incremental risk of extinction or rates of recovery.

Therefore, for hatchery operation, performance standards must address genetic integrity, abundance, and productivity (recruits per spawner) of both hatchery and wild fish. The information provided by these metrics defines the standards to minimize genetic and ecological risks to listed fish. Flagg and Nash (1999) identify strategies for minimizing genetic and ecological risks. Many of these postulated reforms will require applied research and field testing. Hatchery monitoring and evaluation objectives will operate primarily on a subbasin or smaller scale. The monitoring and evaluation must be tailored to each species produced and address practices that impact the scale of effects (i.e., release practices, logistics of broodstock recovery, and straying of hatchery fish).

9.6.5.3.5 Hydropower, Tier 3—Hydroelectric Project and Reservoir Passage Monitoring and Critical Uncertainties

Research, monitoring, and evaluation programs designed to detect the indirect and direct effects of the hydrosystem are fundamentally different than those associated with hatchery and habitat actions. Rather than recovery-goal-directed actions, operation of the FCRPS is ongoing. Whereas it is important to develop and implement experimental operational or system configuration actions within the FCRPS, long-term monitoring and evaluation of background conditions are also essential in light of the demonstrated and hypothesized effects on salmonids. Therefore, the primary goal of the hydrosystem monitoring and evaluation program is to determine survival rates of migrating juvenile and adult salmonids and to identify factors that contribute to mortality, both direct and indirect. These measures will form the basis for evaluating progress toward attainment of the performance standards for hydro survival.

9.6.5.3.5.1 Juvenile Monitoring and Evaluation

Action 185: The Action Agencies shall continue to fund and expand, as appropriate, fish marking and recapturing programs aimed at defining juvenile migrant survival for both transported and nontransported migrants and adult returns for both groups. These studies shall also compare the SARs of transported and nontransported fish to calculate the differential delayed mortality (D), if any, of transported fish.

Documenting juvenile migrant survival is an important measure of performance objective attainment. Current estimates of D have wide confidence intervals, and D values are one of the critical uncertainties that have to be resolved. This action provides the mechanism for implementing Action 47 (Section 9.6.1.3.3), which requires the Action Agencies, in coordination with NMFS, to evaluate delayed mortality of transported versus nontransported fish.

Action 186: The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for comparative evaluations of the behavior and survival of transported and downstream migrants to determine whether causes of D can be identified for the reach between Bonneville Dam and the mouth of the Columbia River.

In addition to further refining estimates of D, investigations are needed to determine if delayed mortality occurs between Bonneville Dam and the mouth of the Columbia River. Differences in estuarine passage timing, behavior, survival, susceptibility to bird predation, and ocean entry timing should be evaluated to determine whether any delayed mortality occurs before ocean entry. Studies linking timing of transport release to passage past predatory bird colonies in the estuary should be conducted. Timing barge releases to pass the bulk of the fish past the bird colonies when birds are not actively feeding might significantly reduce estuarine mortality, particularly for steelhead. Methodologies could include PIT-tag deployments and radio and sonic tracking. This study should be coordinated with other behavioral studies of smolts in the estuary and nearshore ocean.

Action 187: The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies and analyses to evaluate relationships between ocean entry timing and SARs for transported and downstream migrants.

Limited data from transportation studies indicate that adult return rates for transported and downstream migrants can vary greatly by season, by week, and perhaps by day. In general, adult return rates of transported fish are lower for fish moved during the early portion of the outmigration, but return rates can increase substantially for fish transported later. Inriver migrant return trends are the opposite, starting out high and decreasing throughout the season. Understanding the causes of these variations could lead to improved adult returns by relating the

effects of fish transport or nontransport to fish condition or to the physical and biological environment of the Columbia River plume at the time of ocean entry. Linking ocean entry timing to conditions at the time of entry would improve NMFS' understanding of aspects of the plume environment that influence early ocean survival. This could lead to better management practices that would improve survival rates, such as smolt entry timing and flow volume.

Action 188: The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies of PIT-tagged wild stocks from the lower river streams. The studies shall be used to contrast stock productivity and hydrosystem effects.

Schaller et al. (1999) conclude that differences in productivity between upstream and downstream stocks are due to the number of dams through which each stock must pass. Comparing the outmigration timing, physiology, health, and condition of PIT-tagged wild fish from systems such as the John Day River with PIT-tagged wild fish from the Snake River in ongoing studies would enable comparisons between the two groups and assessment of similarities and differences.

Action 189: The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to investigate the causes of discrepancies in adult return rates for juvenile salmonids that have different passage histories through the hydrosystem.

Adult returns from 1995 through 1998 indicate that SARs for smolts that have passed through the hydrosystem vary by year, number of juvenile bypass systems encountered, and specific bypass system, when compared with juveniles that were never detected when passing through the hydrosystem. To date, this is the only empirical evidence of delayed mortality associated with inriver passage through the hydrosystem. In general, SARs decreased as the number of bypass passages increased. These data suggest that juvenile bypass systems may affect adult return rates. In addition, return rates for fish that passed only through Lower Granite Dam are similar to those never detected in the hydrosystem, suggesting that individual bypass systems treat fish differently. This could be caused by a number of factors, including poor outfall locations, increased stress, reduced fitness associated with passage through mechanical components of the systems (such as separators and the PIT tag detection systems), and the tendency for mechanical screen guidance efficiency to increase for fish with BKD. Studies relating the passage histories of individual smolts to changes in physiological parameters, behavioral responses, and survival rates are needed to determine the causes for the observed SARs and identify potential solutions. Furthermore, experimental management of the hydrosystem should be considered to address discrepancies in adult returns associated with passage history. These experiments might include pulling all screens at a dam to eliminate passage through bypass systems, or routing fish directly to outfall sites with full bypass flow so that little to no dewatering occurs.

Action 190: The Action Agencies shall continue to fund studies that monitor survival, growth, and other early life history attributes of Snake River wild juvenile fall chinook.

The Action Agencies, in coordination with NMFS through the annual planning process, will continue to provide funding to monitor wild juvenile fall chinook survival, growth, and other early life attributes. Knowledge of wild fish survival, migration timing, and growth rates is critical as a baseline comparison for studies involving juvenile hatchery fall chinook used as surrogates for wild fish. Supplementation of juvenile fall chinook above Lower Granite Dam is, in addition, resulting in increased parr densities. At some point, decreased growth may occur, affecting the survival of wild fish.

9.6.5.3.5.2 Adult Monitoring and Evaluation

The adult monitoring enhancements in this section are intended to improve basic knowledge about upstream passage survival. They complement and enhance the more specific studies to evaluate and improve adult upstream passage survival called for in Section 9.6.1.6.

Action 191: The Action Agencies shall continue to implement adult salmonid counting programs at FCRPS dams, but shall improve the reporting of these counts.

In addition to the daily counts already provided, the Action Agencies will work through FPOM to improve reporting of winter passage counts for all projects where winter counting currently occurs. These counts will be reported in the same manner as other in-season counts (except that 3-day updates will be acceptable). These changes in reporting methods will be implemented no later than the winter 2000-2001 adult migration. Prespawn, summer-run steelhead are abundant near McNary Dam during the late fall and early winter months. Fallback through the juvenile bypass system at McNary can exceed 50 steelhead per day before screen removal on December 15 (P. Wagner, Washington Department of Fish and Wildlife, pers. comm.). Large concentrations of steelhead have also been observed in late fall near John Day Dam, and adult steelhead are known to pass Bonneville Dam all winter. The reporting requirements described above are designed to provide the level of information needed for decision-making during both normal and emergency fish passage management and consultation, especially during the winter maintenance period.

Action 192: As set out in Action 50 (Section 9.6.1.3.4), BPA and the Corps shall install necessary adult PIT-tag detectors at appropriate FCRPS projects before the expected return of adult salmon from the 2001 juvenile outmigration. These adult PIT-tag detectors shall be used as needed for calculating transport benefits, conversion rates, and SARs for listed salmon and steelhead.

This action, set out in RPA 49 (Section 9.6.1.3.4), is repeated here because it is an important part of the system-wide research, monitoring, and evaluation program. The ability to enumerate PIT-tagged adult salmon and steelhead will allow more accurate assessments of critical adult passage

information, including conversion rates between dams, steelhead kelt survival rates, travel time, and fallback rates with minimal adult handling mortality. This will enable making estimates of SAR transport and other survival studies specified in this biological opinion. Coordination of the schedule for installing adult PIT-tag detectors at FCRPS projects is necessary to ensure that the various studies requiring adult PIT-tag detection capability can be implemented in a timely manner.

Action 193: The Action Agencies shall investigate state-of-the-art, novel fish detection and tagging techniques for use, if warranted, in long-term research, monitoring, and evaluation efforts.

Fish tagging, detection, and tracking technologies suitable for use in assessing juvenile and adult salmonid survival, behavior, and distribution are limited. Key components of this tagging effort are as follows:

- The need to discriminate between hatchery and wild fish (not all hatchery fish are currently marked)
- The ability to differentiate populations and their use of different ocean productivity zones
- The ability to determine growth and survival characteristics based on population, location, and oceanographic characteristics

Development of new technologies may enhance opportunities to conduct necessary research, monitoring, and evaluation activities identified in this biological opinion. Development and application of new technologies should be coordinated with other entities to take into account needs across all life stages of salmonids.

9.6.5.3.6 Hydropower, Tier 3—Monitoring Effects of Hydropower Operations on Estuarine and Early Ocean Habitat

An important, but often overlooked, aspect of the biology of Columbia River basin salmonids is the effect of the FCRPS on their use of estuarine and ocean (plume and nearshore) environments. The FCRPS can have a direct and substantial impact on conditions in these habitats through its alteration of the hydrograph, water quality, and other impacts. Regional analyses have identified these environments as critical to population growth potential and, thus, as appropriate for mitigation actions.

Unfortunately, little is known about salmonid use of these habitats. Of primary importance are the following:

- The contribution of juvenile survival during the estuary/early ocean phase to overall ocean survival

- Cause-and-effect links between estuary/early ocean resources and juvenile survival
- Cause-and-effect links between estuary/ocean resources and adult survival
- The spatial distribution of each stock in the estuary/ocean and the temporal contribution to survival
- The influence of natural variation versus that of humanly caused changes in environmental conditions affecting juvenile and adult survival in the estuary/ocean phase

The distribution of each stock in the estuary/early ocean, survival rates, and natural variation in those rates will largely be addressed through tier 2 population and environmental status monitoring. However, tier 3 studies will be necessary to determine causal links between FCRPS alterations of the estuarine and nearshore ocean environments and salmon population response. In addition, several important studies addressing the following are also needed:

- Enhance and benchmark plume modeling; establish a long-term plume monitoring station.
- Partition the role of the estuary habitat from that of the nearshore ocean in juvenile survival.
- Identify and differentiate physical/chemical versus biological factors that cause mortality.
- Evaluate the influence of altering volume and timing of the historical hydrograph, hydrosystem operations, and the physical condition (bathymetry and structure) of the lower Columbia River and the estuary, as well as the effect on juveniles of the size, shape, and beneficial use of the Columbia River plume in the nearshore ocean environment.
- Determine the extent of indirect, humanly caused mortality in these environments; for example, assess how tern and cormorant populations are affected by hatchery and hydrosystem operations.

To address these critical needs, the following ongoing activities will be conducted:

Action 194: The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to develop a physical model of the lower Columbia River and plume. This model will characterize potential changes to estuarine habitat associated with modified hydrosystem flows and the effects of

altered flows where they meet the California Current to form the Columbia River plume.

Physical characteristics of the estuary such as river flow, hydrograph, velocity, bathymetry, salinity intrusion, and circulation patterns define estuarine conditions. It is, therefore, important to characterize the physical aspects of the estuary and to compare existing and future physical attributes with historical conditions to assess the potential effect of hydrosystem flow regimes on estuarine habitat. Physical changes to the estuary will affect its ecology and, potentially, how salmonids use the estuary for migration, growth, and development. The plume habitat as an extension of the estuary, or as a unique habitat important to Columbia River salmon, will be similarly affected by actions of the FCRPS. Characterization of these effects to assess the importance of historical and current conditions will help facilitate the recovery of all salmon stocks.

Action 195: The Action Agencies shall investigate and partition the causes of mortality below Bonneville Dam after juvenile salmonid passage through the FCRPS.

A long-term research, monitoring, and evaluation plan should be developed to measure mortality that may occur after smolts have passed through Bonneville Dam. The plan will include post-Bonneville mortality that may be associated with passage of smolts through the Federal hydrosystem and the extent of delayed mortality, which is uncertain and central to decisions about hydrosystem configuration and the role of juvenile salmonid transportation. These evaluations should attempt to establish how much of the post-Bonneville mortality is natural and how much is related to other factors, such as hydrosystem passage and fitness.

Action 196: The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate level of FCRPS funding for studies to develop an understanding of juvenile and adult salmon use of the Columbia River estuary. These studies support the actions to develop criteria for estuarine restoration (Action 158), restoration planning (Action 159), and implementation (Action 160) in Section 9.6.2.2.

Estuary use potentially has a major effect on salmonid survival to adulthood. The estuarine ecology of salmon in general and the use of Columbia River estuarine habitat in particular are poorly understood. Juvenile distributions relative to habitat type, food habits, prey preferences, and the growth and physiological condition of juveniles entering and leaving the estuary are important aspects of salmonid ecology in the estuary. Information on these aspects of all salmonid life histories is needed to develop an understanding of salmonid estuary use and any influences of the hydrosystem on flows, turbidity, and nutrient delivery that might, in turn, affect salmonid ecology in the estuary.

Action 197: The Action Agencies and NMFS shall work within the annual planning and congressional appropriation processes to establish and provide the appropriate

level of FCRPS funding for studies to develop an understanding of juvenile and adult salmon use of the Columbia River plume.

Plume dynamics and interaction with the California Current can potentially have a major effect on salmonid survival to adulthood. The plume ecology of salmon and use of the plume habitat are poorly understood. Juvenile distribution in terms of food availability, predators, and performance (fitness, growth, and health) must be assessed in relation to plume dynamics. Information on all salmonid life histories is needed to develop an understanding of salmonid use of the plume and any influences of the hydrosystem on turbidity, nutrient delivery, and habitat attributes that might affect salmonid ecology and survival in the plume.

Evaluating juvenile and adult use of the estuarine and nearshore environments will require monitoring techniques still in the early phases of development. In particular, the use of acoustic (sonic) tags with fixed, towed, or buoyed detector arrays is recommended, as is the continued development of existing technologies such as PIT-tag detector flowthrough trawl surveys. The immediate value of a concerted sampling effort in the estuary and nearshore regions will be development of cause-and-effect relationships between FCRPS flow management and physical conditions (e.g., bathymetry, suspended particulate matter, and temperature) that affect the availability of suitable habitat for juvenile salmonids. NMFS will use this information to recommend changes in flow management operations to improve juvenile survival.

9.6.5.4 Data Management

Action 198: The Action Agencies, in coordination with NMFS, USFWS, and other Federal agencies, NWPPC, states, and Tribes, shall develop a common data management system for fish populations, water quality, and habitat data.

The application of performance standards and measures and the use of offsite mitigation as partial compensation for unavoidable hydrosystem effects will require additional data collection and analysis. Validation of the approach, and of the specific actions taken, will require continual confirmation that these measures are sufficient to avoid jeopardy and facilitate recovery of listed salmonids. Evaluations of actions taken, the feasibility of future actions, and factors affecting mortality will depend on the availability of scientifically defensible findings. Development and implementation of offsite mitigation will require close coordination with relevant state actions such as water management and water quality compliance mechanisms. It will also require close coordination with Federal land managers and EPA. NMFS' past year of work on the CRI analysis has focused the need for a single comprehensive system to ensure integration of monitoring and evaluation information described in this section with information from other sources. This includes, but is not limited to, requirements described in other sections of this biological opinion.

9.6.5.5 ESA Section 10 Permit Authorization for Research/Monitoring Pursuant to the RPA

Scientific research and monitoring are critical parts of the overall program to minimize take of ESA-listed anadromous fish species resulting from the operation of mainstem FCRPS projects on the Columbia and Snake rivers. These activities are necessary to satisfy elements of the RPA described in individual subsections. In addition, specific terms and conditions related to research and monitoring efforts are proposed for inclusion in the incidental take statement of this biological opinion. The required research/monitoring activities will provide data and information necessary to develop annual management strategies to help mitigate hydropower system impacts and to answer important questions related to system operations. Special project operations for required research/monitoring activities that deviate from normal operations described in the Corps' Fish Passage Plan will, however, continue to be coordinated with interested parties through the annual planning process and in subsequent ESA-related coordination with NMFS.

The identified scientific research/monitoring activities are only a subset of the activities that will be funded by the Action Agencies, primarily BPA and the Corps. Those agencies are also responsible for complying with Section 7 of the ESA because they fund activities that may affect threatened or endangered species or designated critical habitat. To streamline the permitting process and avoid delaying critical research, monitoring, and evaluation measures, this biological opinion considers the effects of the activities that would be funded and will fulfill each individual Action Agency's Section 7 consultation requirement. Not all activities are included, because not all are well-enough defined to identify the proposed methods and, from that, the estimated levels of take. As new study plans are developed in accordance with this RPA, NMFS anticipates the need for additional Section 10 research permits.

While some research/monitoring activities associated with the RPA cannot be determined in sufficient detail until annual plans are prepared and approved, the following describes specific research activities that can be anticipated now, based on the elements of the RPA described in Section 9.6.1.

Action 199: The Action Agencies shall implement the specific research/monitoring actions outlined in Appendix H.